

S. S. PHILBRICK Jr.

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MAKING PAPER

A series of articles on the manufacture of pulp
and paper compiled from lectures to the
Crown Willamette Paper School

by

The superintendents, foremen and others of the
Crown Zellerbach Corporation

Edited by

A. G. Natwick - E. H. Nunn - M. K. Rawlings

SECOND EDITION

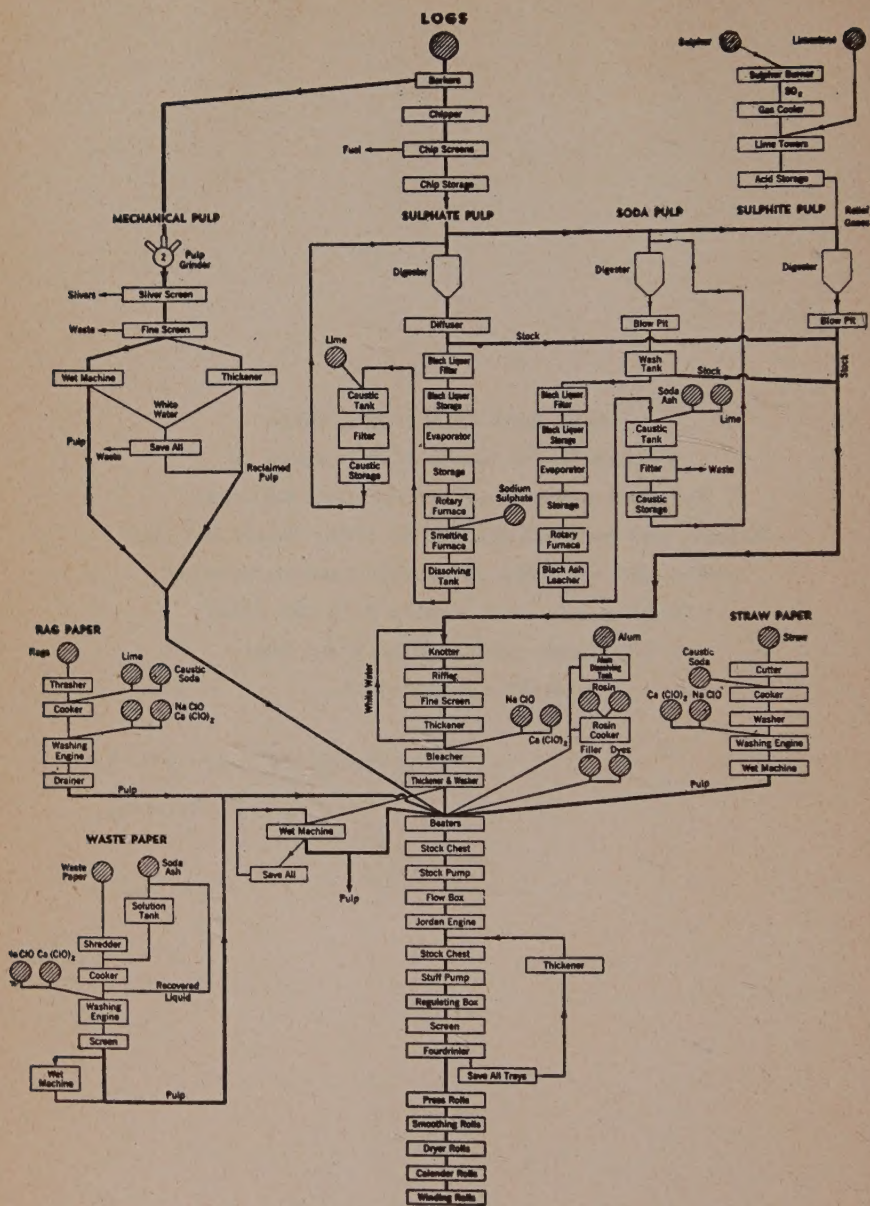
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*—thou hast most traitorously
corrupted the youth of the realm, in
erecting a grammar school: and whereas,
before, our forefathers had no other books but the
score and the tally, thou hast caused printing
to be used; and, contrary to the king,
his crown and dignity, thou hast
built a paper mill.*

“King Henry VI” - II - IV - 7

—Shakespeare

MANUFACTURE OF PAPER



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PREFACE

The paper industry is a powerful factor in the industrial structure of this nation. With an annual consumption of from one-third to one-half that of steel, and with its products so widely distributed, its progress is a dependable barometer of the prosperity of the country at large.

It is a healthy growing industry—a young industry in some respects, yet steeped in the tradition of history. Striking indeed is the expansion that the industry has seen in the past century and the tremendous increase in the yearly consumption of paper in the United States which has grown since 1820 from a few pounds per capita to well over two hundred pounds.

By far the greater part of the increase in paper consumption has occurred during the last fifty years and during that period the affairs of the Crown Willamette Paper Company have been closely interwoven with the development of the industry.

From an historical standpoint, a stock company known as the Camas Colony Company organized in 1883 by H. L. Pittock and several others for the purpose of lumber manufacture was the beginning of the present Crown Willamette Mill at Camas. Extensive property, including timber lands and a water power site, was acquired by the Colony Company and in 1884 the Columbia River Paper Company was started in conjunction with the sawmill operation to manufacture newsprint for the Portland Oregonian.

In 1888 a parallel enterprise was developing in Oregon, where the Willamette Pulp & Paper Company was organized to build a newsprint mill at Oregon City.

In 1889, a group of prominent business men from the San Francisco district organized the Crown Paper Company and built a paper mill adjacent to the Willamette Pulp & Paper Company's location in Oregon City. Ten years later this same group organized the Floriston Pulp & Paper Company and built a mill at Floriston, California.

In 1892, the Lebanon Paper Company was formed to manufacture wrapping paper at Lebanon, Oregon.

In 1905, the Crown Paper Company and the Columbia River Paper Company were merged to form the Crown Columbia Pulp & Paper Company, later, in 1912, absorbing the Floriston Pulp & Paper Company, at which time the enterprise was renamed the Crown Columbia Paper Company. In 1914, the Lebanon Paper Company was also absorbed and with the Willamette Paper & Pulp Company formed a group which became known as the Crown Willamette Paper Company. In 1928, the interests of the Crown Willamette Paper Company and the interests of the Zellerbach

Corporation were consolidated and in 1937, merged to form the present operating company, the Crown Zellerbach Corporation.

We can look back with pride at those self-reliant and hardy fellows who without benefit of modern mechanical improvements, and in the face of the utmost difficulty and danger, carved a new industry out of a forest wilderness here fifty-five years ago.

The past several years have seen the development of an educational program fostered by the present company which has been the basis for the compilation of this book. The need for dispensing information which was acquired only by long years of experience has been recognized by the industry for many years.

The problem of presenting this information has received considerable attention and in recent years was perhaps most completely met by the five volumes on The Manufacture of Pulp and Paper prepared under the direction of the Joint Executive Committee on Vocational Education representing the pulp and paper industry of the United States and Canada, and used as a basis of correspondence courses and vocational training where classes were organized. The Camas Paper School was organized in the fall of 1933 and although the value of the available literature was recognized, our educational program seemed to call for something more specifically adapted to the operations of this plant. To that end, the foremen and supervisors of the various departments were called upon to deliver lectures to the different classes and their information along with other general papermaking information comprises the chapters of this book.

Without full and enthusiastic support and many hours of hard work by the men who have lectured to the school and written the chapters found in this book, the Paper School could not have existed, nor would this volume have become available.

We know that the continued success of the Paper School and the knowledge that their experience as revealed here is an inspiration to the young men entering the industry, will be a source of gratification to those who have contributed to make this edition possible.

A. G. NATWICK.

CHAPTER I

LOGGING OPERATIONS

By E. P. STAMM

I

HISTORY OF THE LOGGING INDUSTRY

No doubt logging dates back to prehistoric times, since one of the first needs of man was to find shelter. We are informed in history that his first effort in this direction was to find caves to afford shelter from the elements, and in later ages he resorted to the construction of log cabins. When we come down to Biblical times, we are informed that when King Solomon built his Temple, he went into the "logging business" on a grand scale and cut the Cedars of Lebanon for use in its construction.



Fig. 1. Old Way of Logging

In our own country, logging had its origin in the New England states, the Pilgrims from the "Mayflower" having cut trees to build their log cabins, farm buildings, etc., and to clear agricultural land in the immediate vicinity. From here, logging moved westward to the Lake states, southward along the Appalachians, and thence westward to the Pacific Coast. Today, we have a limited amount of logging in all of these districts, with the major portion taking place on the Pacific Coast, although the Southern pine district in recent years is running a close second.

The logging industry requires a varied type of investigation and development, in that it has become a much more complicated business than it was in previous decades. The early pioneers had only to fall their trees immediately adjacent to the place where they were needed, or on the banks of navigable streams. When they were forced to go farther inland, it was still within the range of hauling by means of horses or oxen. Later developments lead to the use of wagons and sleds which were used to haul logs on crude roads built upon the ground or upon the snow and ice, and, on this basis, logging became quite a business, particularly in the pulp areas of the Northeast. Today, modern logging requires considerable ingenuity, due to the fact that most of the remaining timber stands on very rough, precipitous land and can only be reached by means of logging railroads or elaborate truck roads.

We shall endeavor to give a detailed description of the principal factors which must be considered in the purchase of timbered property, plans for the development of such a property, and the actual logging of same.

II

SELECTION OF A TIMBERED PROPERTY FOR PURCHASE

Quality

One of the most important factors in the examination of a timbered area is that of quality, as this is the primary consideration whether it is to be used for lumber or pulp. Quality examinations are made by carefully observing the size of the trees; whether or not the trunks are surface clear; whether there are indications of rot, black knots, or other defects; and whether the foliage is in a healthy condition. These observations of the standing timber are supplemented by the cutting of wind-felled trees, rolling out blocks several feet long cut out of various parts of the trunk of the tree and split up into pieces, in order to examine the density of the wood; presence of knots, stain, rot, pitch blisters or rings and other defects. Checking sample plots for quality in a systematic manner over the whole tract gives a reasonable appraisal of the value from a quality standpoint.

Quantity

The next consideration is that of quantity, as the stand per acre and its consistent distribution over the entire timber tract are very important factors in justifying the construction of railroads, road improvement, purchase of logging machinery, and other economic reasons. For instance, it can readily be seen that if it costs \$12,000.00 per mile to build a road, the cost per thousand feet would be far greater in a light stand of timber than it would be in a heavier stand. Likewise, the moving of logging

machinery, rigging of spar trees, and other preparatory measures, would be greatly increased in a light stand of timber. Generally, the better quality timber occurs where there is a reasonably heavy stand, as the density of the foliage shuts out the sunlight and causes the trees to shed their branches when they are comparatively young, and, in this manner, a better quality of timber is produced than in sparsely timbered areas.

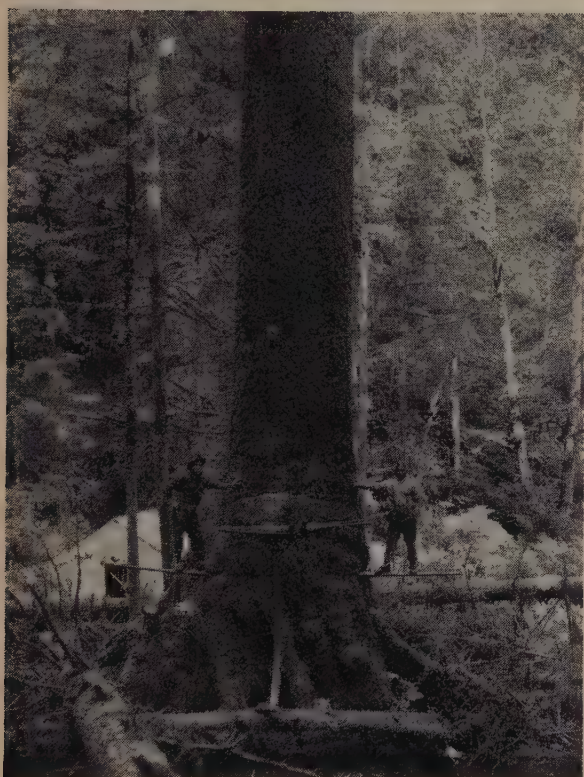


Fig. 2.
Falling a Large
Spruce Tree

Risks

There are a variety of risks involved in the ownership or purchase of timbered areas, such as danger from insects, fire due to hazardous conditions in the vicinity (bad slashings, frequent lightning storms, proximity of stump farmers who burn ferns and weeds to secure fireweed bloom for feeding their bees) and other similar hazards. Also, high winds are an important factor because, if there are bad blowdowns on an area, these usually increase each winter and, in addition to the loss of timber, they create a bad fire hazard. Floods and slides are somewhat of a factor, although not as serious as those previously mentioned.



Fig 3. High Climber Topping a Tree

General Topography

It is important that a careful study of the topography be made in conjunction with the study of the previous factors, as very rough, precipitous ground with frequent outcroppings of hard rock and consequent heavy railroad construction, can make certain tracts of timber so uneconomical to log as to make the logging of such tracts practically prohibitive during the present decade, with prices now prevailing. Such areas may be economically logged if and when timber values are greatly increased, but this may mean holding such timberlands for a long period of time and having to pay high taxes, as well as to carry all of the other incidental risks.

In order to get a line on the topography of a tract, the cruisers usually make a sketch map indicating the principal water courses, the main ridges and control saddles which would limit the location of railroads or truck roads. In recent years, the cruisers' maps have been supplemented by aerial photography, which, by the ingenious use of optical instruments, makes possible the working up of reasonably accurate topographic maps in the office, indicating the contours of the country. The method most generally used, and the one which our company has followed, has been to keep a staff of logging engineers in advance of the logging, making accurate topographic maps of the timbered areas. These maps are used to work out detailed logging plans, railroad location, etc., and are of the utmost importance, being one of the most valuable developments in the last twenty years.

In making topographic maps, the method used by our engineers is to run a transit and level survey around a block of two sections, then, with a longitudinal level and 300-foot chain, measure the slopes and distances, spot the contours on a waterproof sheet carried in the field, building up an accurate contour map by a series of strips 300 to 330 feet wide and one mile long, all of which are assembled and made into a composite map of the whole area.

III

TENTATIVE PLANS FOR THE DEVELOPMENT OF A PROPERTY

One of the most important considerations in the development of any property is the outlet route, that is, the route by which the timber is to be taken from the tract and delivered to the ultimate consumer or manufacturing plant.

This plan may be divided up into several different transportation methods and, generally, the most desirable route is to get the timber to a navigable stream, since most of the mills are located on such streams and

consequently water offers the cheapest transportation. Recently the writer examined a tract of timber where there were no less than sixteen possible outlet routes, all of which had more or less merit. However, after making a detailed study of the development costs of the transportation system, estimates of the operating costs over these routes, hazards due to wind, towing, rafting, etc., it was quite easy to boil these sixteen routes down to a matter of five. A casual observation of these routes would have lead one to believe that at least two had very outstanding advantages, until surveys were made and a careful cost analysis considered, at which time it developed that what was considered as about the third most desirable route actually proved to be by far the most desirable. Many technical factors enter into such a selection, factors that are too involved to be of general interest.

IV METHOD OF TRANSPORTATION

Having determined the most desirable route, the next question is the selection of the method of transportation, which, generally, would consist of railroads, truck roads, and flume or river driving. With the complication of moving far back into the timbered areas, sustaining a modern village, delivering supplies and moving heavy machinery, flume and stream driving is practically obsolete and will not be considered further.

Logging railroads are the generally accepted method of transportation in areas carrying large volumes of timber to be moved over one definite route and where it is possible to have reasonable grades and construction costs. Where these factors are economically possible there is no other system of transportation that can compete with the logging railroad.

Truck logging has become an important factor on the Pacific Coast in recent years, and its greatest advantage is in taking out small tracts of timber conveniently situated near existing roads or highways, on which the volume of timber is too limited to justify the acquisition of rights-of-way and the expense of railroad construction. As an example: many truck loggers move in and log a small tract of timber in a matter of a few months, and may operate in a dozen different small tracts over a period of several years, whereas a large operator with a railroad transportation system frequently logs in one area from five to fifty years.

One of the phases of logging which has had limited application is the combination of truck and railroad operation, the railroad being used for the mainline and heavier timber stands, the truck roads and trucks to bring in timber from the scattering outlying areas to the mainline railroad.

V.

TERMINAL FACILITIES

The selection of terminal facilities is of considerable importance and varies according to whether the logs are to be delivered direct to a mill by rail or truck or whether they are to be delivered to a navigable stream and rafted for towing to the mill. In our operation, with large mills of permanent construction to supply, it is generally necessary to dump the logs into the water and raft them either in flat rafts for towing in quiet river waters, or in cribs for ocean towing, such as is done on the Olympic Peninsula and at Ocean Falls. In such locations it is important that the rafting grounds be sheltered from severe storms and that the rafts be made up in comparatively quiet waters in order to get the most economical results. Likewise, in many such locations, supplies, food and machinery must come in through such terminal facilities, which accordingly form an important link in the general transportation scheme. Where it is possible to deliver direct to the mill, it is generally desirable to have a mill pond for economical storage of the timber.

VI.

SIZE OF MOST ECONOMICAL OPERATION

The size of an economic operation depends upon many factors, among which are the following:

- a. The capacity of the mill or mills to be supplied.
- b. Investment necessary to build a mainline railroad or major transportation system.
- c. The question of taxes.
- d. Period of amortization and general life of manufacturing plant.

VII.

SELECTION OF LOGGING EQUIPMENT

This subject is one that has undergone frequent changes during the past twenty-five years, and, with the thought of sustained yield and better forest management foremost in the minds of all operators, there has been a considerable tendency to use tractor equipment wherever possible in order to log selectively and leave the younger trees to grow for future cutting. However, much of our timberland is so rough and precipitous, and subject to such excessive rainfall, that it is impossible to operate tractors, so that in these areas it is necessary to use either skidders, slack-

lines or other cableway equipment to transport the logs over the precipitous ground and finally get them to the railroad or trucks. There has been a decided trend in past years toward the use of internal combustion engines and, very largely, Diesel powered units, especially for such equipment as operates away from the railroad track and in locations where the movement of fuel to the equipment is quite expensive.

VIII. HOUSING FACILITIES

In the larger timbered areas there are rarely ever housing facilities for the personnel, so it is necessary for the company developing such a tract to provide housing in the form of bachelor quarters for the single men and family houses for at least the key men of the organization, as well as kitchen and dining room facilities, proper sanitation, water supply, schools, roads, electric lines, and, where the locations are quite remote, doctors, grocery stores, post office, recreation facilities, etc. In other words, all the conveniences of a modern village.

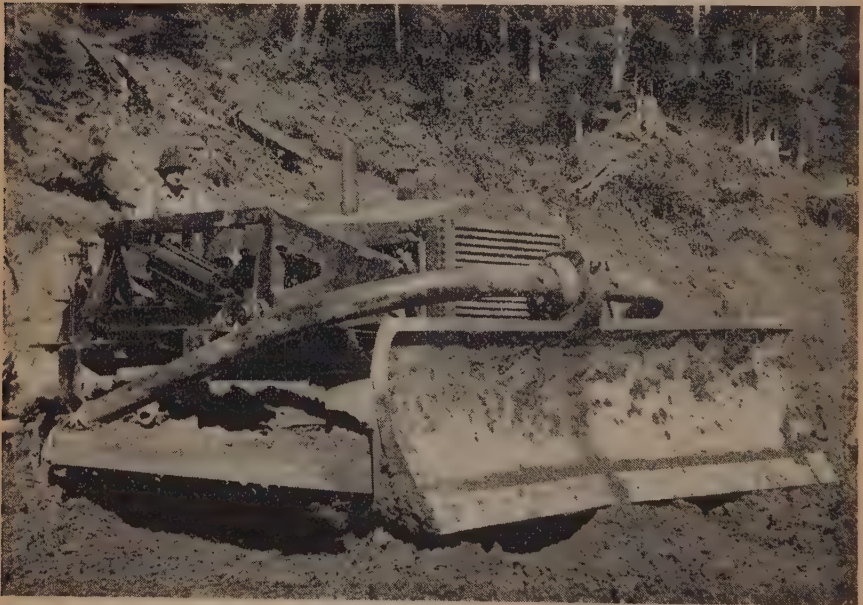


Fig. 4. Grading With a Bulldozer

In order to properly locate such a village, considerable care and attention must be given to the secondary transportation arteries so that

the housing facilities may be as conveniently situated as possible for a long period. In recent years, our own company has constructed many miles of auto road in order to make the logging camps accessible and to give the employees an opportunity to get out to the nearest towns for recreation. One of the major problems in building a camp or townsite for logging employees is that in many cases such a village may have to be moved at least several times during the life of the operation and, when this is necessary, houses, buildings, and all equipment are loaded onto railroad cars and moved to the new site, rehabilitated, and a comfortable village established again. Such a move, of course, calls for a repetition of water supply, sanitation, electric lines, clearing of grounds, etc.

IX.

LOCATION AND CONSTRUCTION OF RAILROAD OR TRUCK ROADS

When final decision has been made as to the proper transportation method, and housing facilities have been at least partially established, the construction of a transportation artery is next in line. Here, again, the engineers make railroad surveys, locate the roads or railroads, and construction is started. This calls for the falling of trees to clear rights-of-way, the construction of culverts and drainage, grading of the road beds, track-laying, ballasting, bridge construction, etc. A staff is maintained practically the year around to do this type of work, the greater part of which must be done during the summer months on account of the heavier rainfall during the winter which makes construction work almost impossible.

X.

ORGANIZATION OF PERSONNEL

Just as in any other industrial enterprise, the personnel is organized, generally by the selection of a superintendent for the operation, a chief engineer, a construction superintendent, a logging foreman, a head scaler, master mechanic, and various other department heads to take charge of falling and bucking, yarding and loading, transportation, booming and rafting, etc.

Having now purchased a tract of timber, having gone through all of the various stages of development, and having selected a personnel, we will now pass to the routine operation of logging.



Fig. 5. Wash Line Bringing in a Turn

XI LOGGING OPERATIONS

Falling and Bucking

After the railroad has been constructed, the engineers lay out the various logging settings, and the cutting foreman directs the timber fallers and buckers to cut the timber in the areas as outlined by the engineers. Here, first, windfalls are bucked and any commercial logs salvaged, then the standing trees are felled, scaled, limbed, bucked, and made ready for marketing.

Cold-Decking

The next operation consists of stacking or cold-decking in locations where logs are so far out of reach of the main logging units and railroad as to be uneconomical to reach by railroad. A Diesel or gasoline-powered donkey is moved out to the inaccessible areas, usually consisting of 20 to 100 acres, and the logs are yarded to one or more cold-decks which can be reached from the truck roads.

Yarding and Loading

As we mentioned at the beginning of this chapter, yarding and loading has progressed from the use of animal power, man power with the aid of



Fig. 6. Single Tong Loading Boom

jack screws, to the use of tractors and cableway systems. In the rougher ground, we cold-deck with a hi-lead system and swing or relay from the cold-deck to the railroad with a cableway system where the logs are loaded for transportation to the mill or in the water. The yarding of these logs requires the movement of heavy machinery on large sleds over very precipitous ground and calls for the utmost skill and care to avoid damage to property or accident to personnel. In recent years, these risks have been somewhat minimized by the use of bulldozers in preparing rough roads on which to move these heavy machines which has not only reduced the risk but has expedited the movement to a very large extent.



Fig. 7.
Skidder

Transportation

As this subject has been quite thoroughly covered, it will suffice to say that the logs are brought in from the various landings where they are loaded on cars or trucks and transported to the terminal destination, where they are dumped into a pond or river.

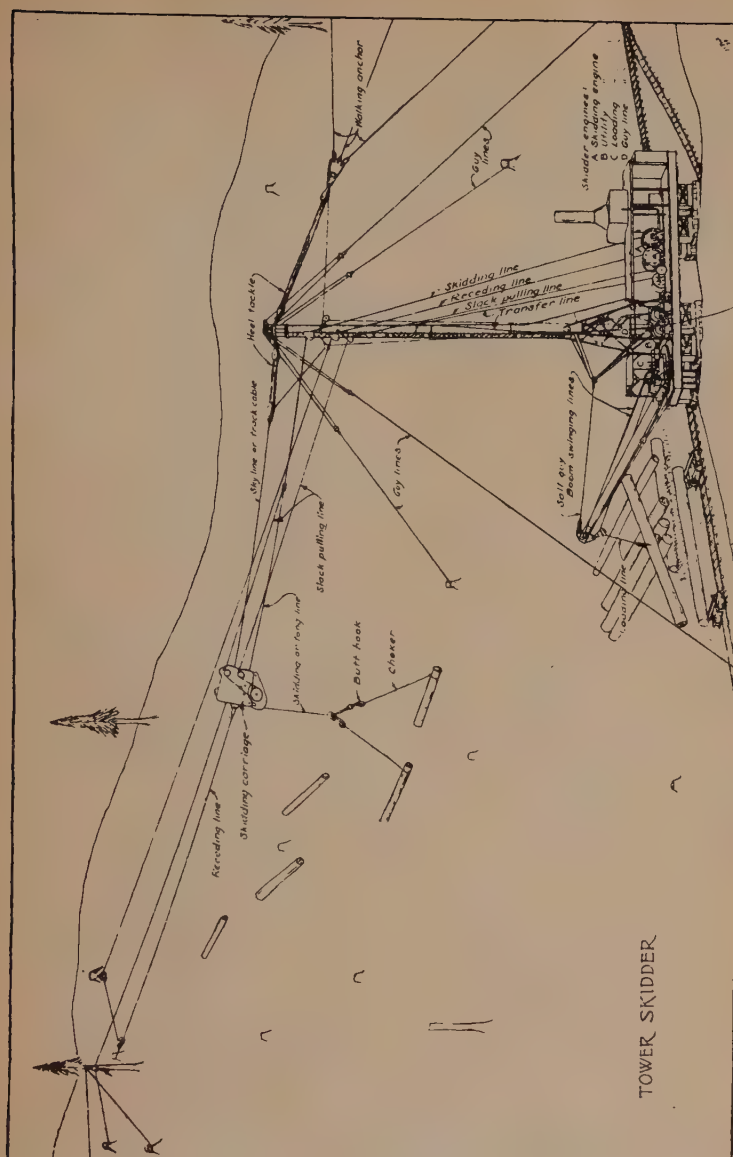


Fig. 8

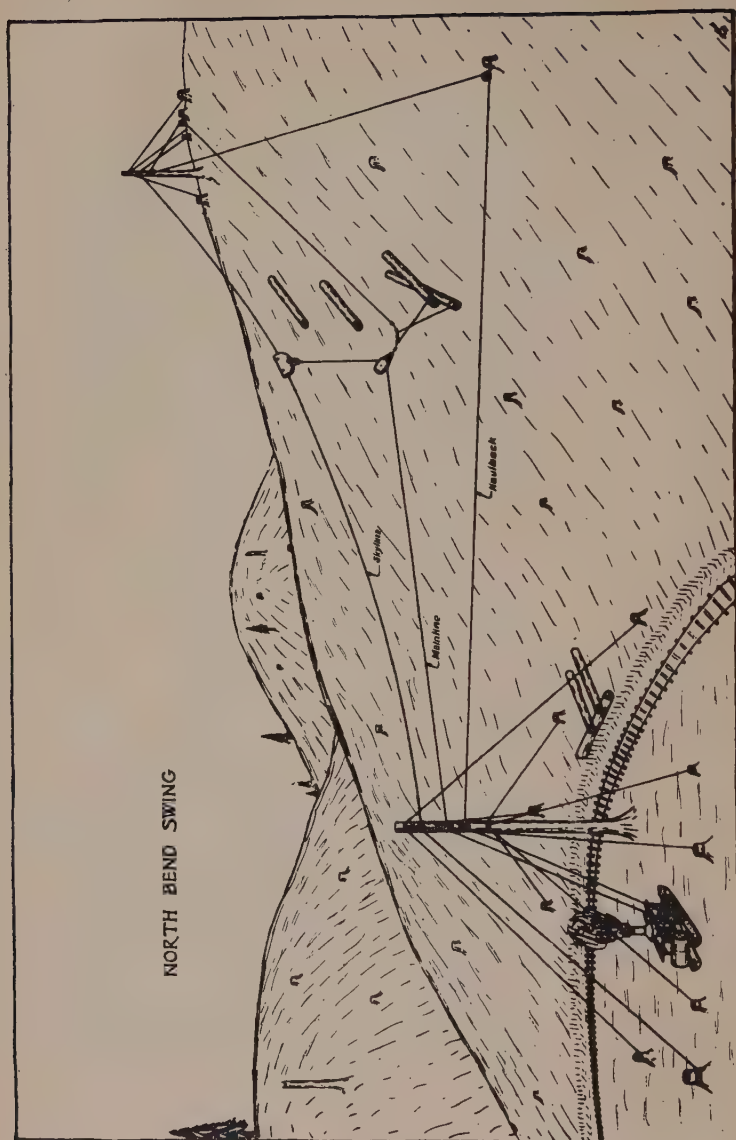


Fig. 9

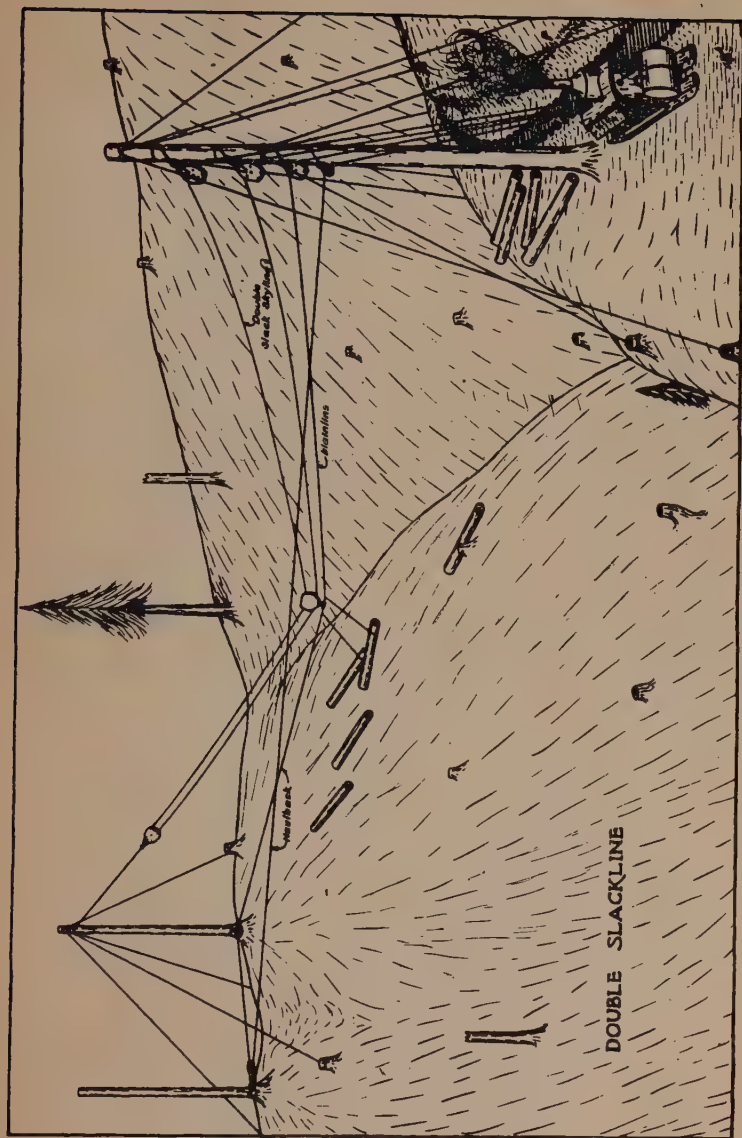


Fig. 10

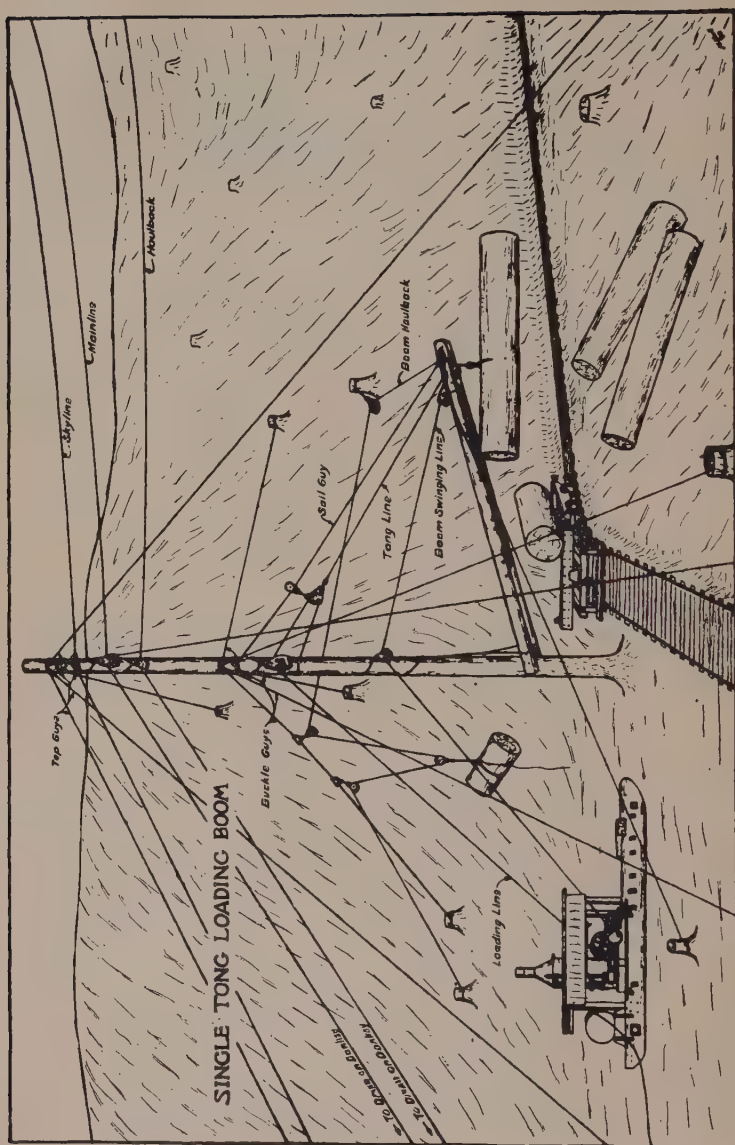


Fig. 11

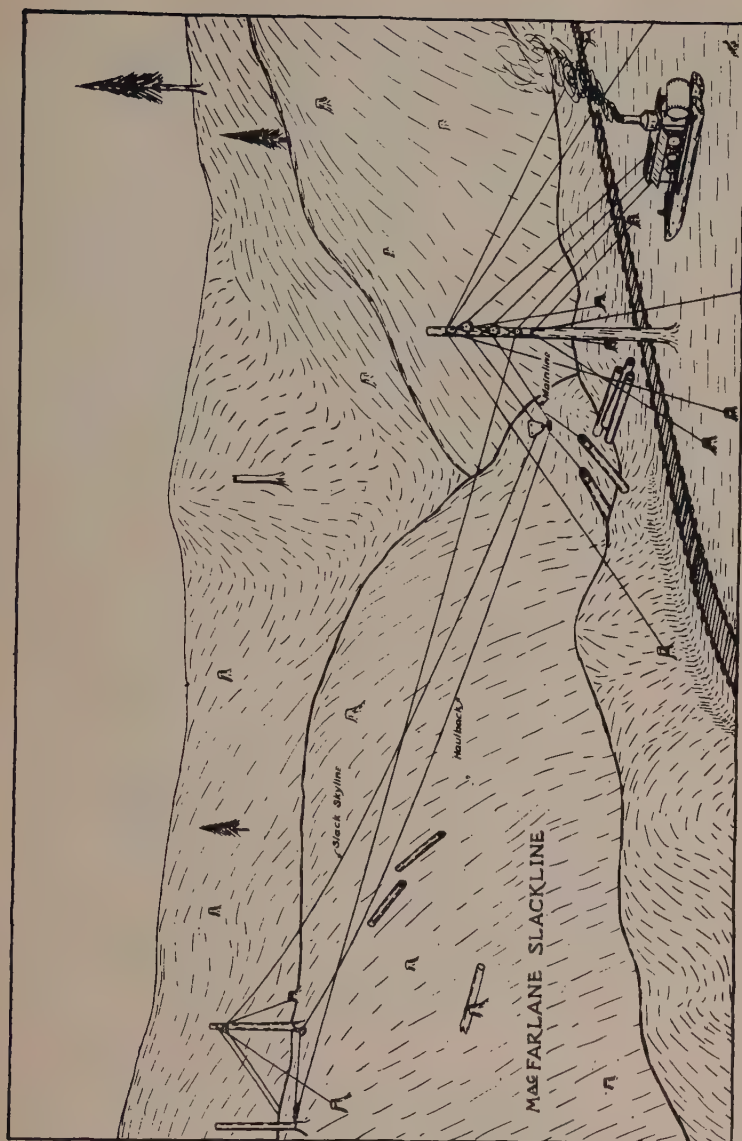


Fig. 12

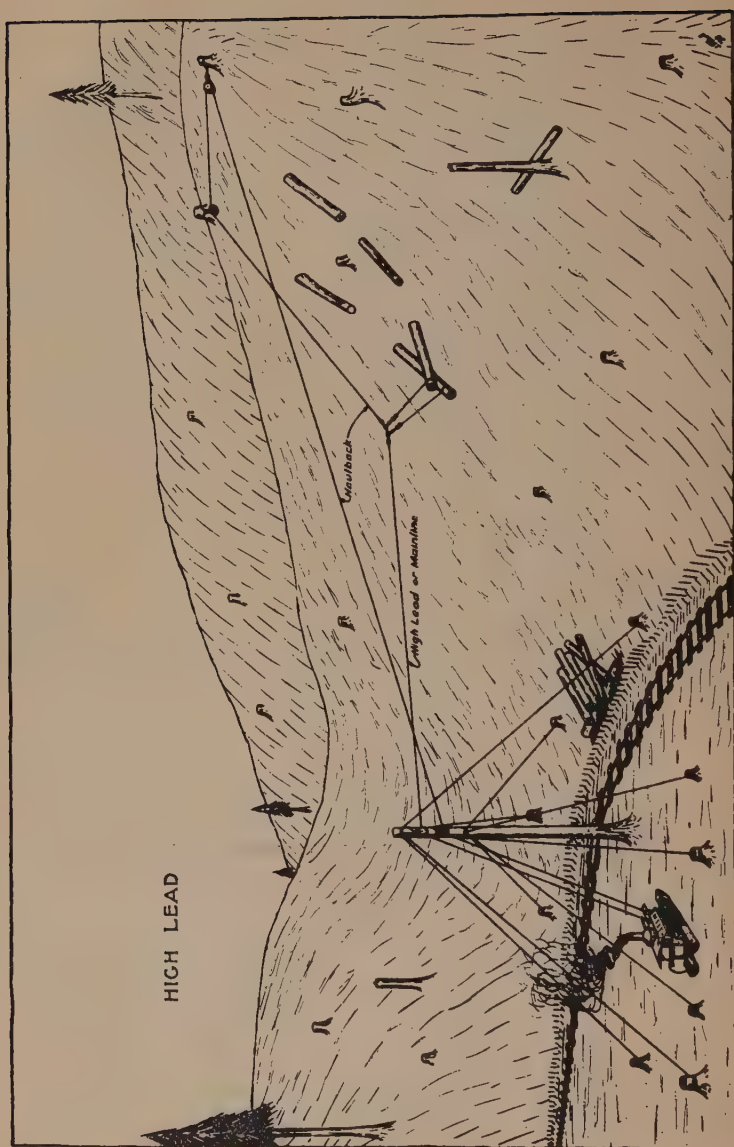


Fig. 13



Fig. 14. Selective Logging With Tractor

Booming and Rafting

The logs are here segregated according to species and by grade within the species, then rafted to be used for various purposes. Some of the logs are sold for lumber manufacture and plywood, the pulp species being used in our own operation. In some of our timber stands, we have fir, hemlock, spruce, cedar, larch, white fir, and a sprinkling of alder and maple mixed in fairly even proportions.

Towing Logs

As the rafts are completed, the towboats take them to our pulp mills where they are broken down and made into pulp and paper. The sales species of logs and the species which are not suitable for pulp, are sold to various lumber manufacturers and constitute a considerable portion of our logging operations.



Fig. 15. Loading With Loco Crane

XII MANAGEMENT OF TIMBER RESOURCES

Having gone through the various stages of acquisition, development and logging, we are faced with other problems, such as slash disposal, regeneration of a new timber crop, selective logging, and future timber supply. The amount of slash or debris left on a logging area after the merchantable timber has been removed is somewhat dependent upon the condition of the forest before logging is begun. Many of our timbered areas are over-ripe and decadent, and untold numbers of dead trees are standing as snags or lying as windfelled trees on the ground, and have little economic value. After the merchantable timber has been removed, the debris, branches, decayed portions of logs, windfalls, snags, and other forest

debris presents a most repulsive appearance and has sometimes been referred to as "No Man's Land." However, the only constructive thing to do with this material is to burn the inflammable portions so as to reduce future fire risks to a minimum.

A new timber crop may be started either by leaving a number of seed trees standing in the area or by planting seedlings which have been grown in a nursery and restocking the area for a new forest.



Fig. 16. Logging Train

XIII

SUPPLY OF PULPWOOD SPECIES

Western Washington and Western Oregon have twenty-two species of trees that occur in any considerable quantity and might be considered as raw material for pulping. This is exclusive of Douglas fir, pines, cedars and hardwoods (except cottonwood).

At present, the most important pulping species are spruce, hemlock, balsam firs and cottonwood. There are two species of spruce growing on the Coast, Sitka spruce and Engelman spruce. The latter as yet is not much utilized as it occurs mostly in high country. Likewise, there are two

hemlock species, western hemlock and mountain hemlock, the latter also growing above 5,000 feet and hardly touched yet by logging operations. The balsam firs include six species, the most common being lowland white fir. The others, silver fir, noble fir, shasta fir, white fir and alpine fir are good pulping species but, like mountain hemlock and Engelmann spruce, are high altitude woods that have not as yet been reached in logging to any extent.

Cottonwood was the first raw material used for pulp manufacture in the Northwest. This was gradually supplanted by Sitka spruce, which was for many years the dominant pulpwood species. Western hemlock was later found to be an excellent pulpwood and, since its stands are heavier than spruce, it is today the principal pulpwood species. Hemlock is a hardier and faster growing species than fir, and, as a result, in second growth areas it is more predominant than in virgin forests. This means that reforestation will gradually develop fine stands of hemlock timber.

A comparison with Southern pine resources is interesting. There are now approximately 36 billion board feet of standing pine in the South on some 17 million acres. Western Washington and Oregon have some 240 billion board feet, about 70 percent of which is in Washington and practically all of which is within fairly easy reach of tidewater. We have heard much of the advantages of rapid growth of Southern pine. However, it is interesting to note that slash pine has an annual growth of 86 cubic feet per acre compared to 178 cubic feet per acre for Western hemlock. In other words, when calculated on an acreage basis, Western hemlock grows twice as fast as slash pine.

The Pacific Coast forests are favored with comparative freedom from high velocity winds and temperature extremes, and have a well balanced annual precipitation of some 60 inches or more, which in itself is a distinct factor in minimizing fire hazard. Coast forests are rated as the finest and heaviest stands of timber in the world.

Alaska has a reserve pulpwood supply of some 80 billion board feet as yet practically untouched, although much of it is now mature timber. Some 80 percent of this is Western hemlock and about 20 percent Sitka spruce. It has been estimated that the combined forest resources of Oregon, Washington and Alaska could produce a perpetual self-sustaining yield of pulpwood sufficient for an annual paper production of $2\frac{1}{2}$ million tons.

The Pacific Northwest Forest Experiment Station at Portland estimates that Western Washington and Western Oregon forests are at present growing at the rate of $1\frac{1}{2}$ billion board feet per year. The current annual consumption for pulpwood is about one-half billion board feet, and for lumber something like one billion, so the situation is reassuring from the

standpoint of forest depletion.

The question of devastation by fire is always an uncertain issue. For example, two fires in Oregon in 1933 destroyed 11 billion feet of standing timber; nearly as much as the entire annual lumber cut in this country.

However, with reasonably effective fire and pest prevention, and with further improved methods of selective logging, thinning and slash disposal, much forest now more or less stagnant with mature or over-ripe growth, will be converted into healthy young growing stands. It is estimated that when all forest lands are in prime producing condition in the future, that the potential annual growth will reach seven billion board feet.



Figure 17. Raft of Fir Logs

XIV SELECTIVE LOGGING

As an alternative to leaving seed trees and planting seedlings, considerable experimentation has been done with the idea of handling a timbered area much as one might handle a vegetable garden, by thinning out the trees through the selection of the mature and larger trees and leaving the smaller and immature trees to grow. The residual stand grows with considerable acceleration after the overtopping and decadent trees have been

removed. A forest properly thinned in this manner would increase its rate of growth to the extent that successful partial cuttings could be made over a 15 or 20-year cutting cycle, and the area kept on a sustained yield basis. The rate of growth is naturally high in the Coast fog belt from Tillamook, Oregon, to the tip of the Olympic peninsula, and under favorable conditions, hemlock will reach a diameter of 15 inches in 25 years.

One of the fallacies of public opinion is the thought that the cutting of timber is a crime against nature and man. Again comparing a timbered area to a vegetable garden—of what value would a vegetable garden be if, when the plants had reached their maturity, they were to be left in the garden to gradually decay and return to the earth without performing any useful purpose? So the best management of a timbered property calls for careful cutting.

As an illustration along this line: A timbered area could well be compared to the population of a large city which is made up of old people, probably of the retirement age, supplemented by those of middle age in good health and active, young people of college and high school age, grammar school age, and so on down the line to infants in arms. If all of these various groups are properly balanced, we have the nucleus of a healthy and progressive population to carry on over a long period of years, but, if there should be a decided deficiency in any of these groups, there would be a weak link in the chain of balanced population. The ideal forest could well be compared with the population of such a city. There should be trees of all ages in the group, and, after the older trees are removed and the younger ones carefully thinned out, there would always be a very healthy, growing group of trees, and this process could be carried on for indefinite centuries. This has been demonstrated by some of the German and Australian forests where cutting has been going on for as long as 1000 years in one location, with just as good timber crop today as there has been in any generation past.

With over-mature forests and a large volume of decadent material, it is essential that the decadent material be removed or destroyed and that the forest be put in order over a period of years so that the best results may be obtained in the future. Again, in some of the extremely mountainous and precipitous country, such as the areas located well up on the slopes of the Cascades, which are heavily timbered, the ground is so rough and costs so excessive, and there is such a large amount of defect prevailing, that only clear cutting and reseedling is possible. Here, the debris left after logging will have to be burned in order to ensure future crops.

In order to accomplish the greatest security for future timber resources, our Company now has a large volume of old-growth mature timber and also a large area of young, healthy second-growth timber, and this is supplemented by planted areas of 3 to 20 years in age, which are forming the nucleus of a fine future forest. Much thought is being given and definite progress is being made in building up a substantial timbered area which, if properly managed, should give a continuous timber supply as long as the Company wishes to operate their present properties.

CHAPTER II

STRUCTURE AND PROPERTIES OF WOOD

By R. G. MISPLEY

Effect of Wood Quality

Wood quality is a most important variable affecting pulp quality and resulting paper characteristics. The strength of sulphite pulp, for example, will follow changes in wood quality much more exactly than variations in acid concentration, digester pressure, temperature, or cooking time within ordinary operating limits. The International Paper Company recently made a very intensive and exhaustive survey of these relations and found that seasonal changes in strength directly followed changes in the percentage of spruce wood used in their process. A similar investigation was made at Port Townsend last year in which it was found that the rate of hydration and general quality features of both kraft pulp and paper were tied in with seasonal variations in wood quality. They found that wood cut during the loose bark period, preceding the formation of springwood by about two months, caused increased chemical usage, additional beating power and reduced beater capacity due to abnormal swelling of the fiber. So it can be seen that before paper of desired quality can be produced by properly controlling the production and behavior of pulps, it is necessary to first understand the influence of the quality of wood, the most important raw material.

Commercial Species

There are two main classifications into which trees are grouped, first the coniferous or evergreen trees and second the deciduous or broadleaf species which lose their leaves in winter. Examples of the former are larch, fir, spruce and hemlock. Typical broadleaved woods are cottonwood, basswood, maple and birch.

The use of wood as a raw material for the manufacture of pulp and paper in this country dates back to the middle of the nineteenth century. The first species used were aspen and basswood. These and other broadleaved woods are still preferred in soda pulping but were quickly replaced by spruce for groundwood and sulphite pulps. Thirty years ago the pulp and paper industry did not regard hemlock as offering spruce any competition as a pulpwood. However with the gradual growth of the industry in the Northwest, hemlock increased in importance until it finally occupied the predominating position. Ten years ago it was considered impossible to

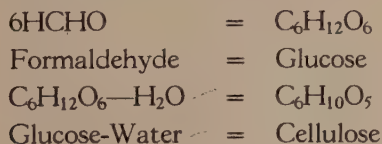
produce a high alpha pulp from hemlock. However, applied research and improved pulping practice has hurdled this obstacle and a large tonnage of Washington bleached hemlock sulphite pulp of alpha cellulose content of 90% or over is being absorbed by the rayon industry. In the past two years the pulp and paper industry has again changed its course. This time to the pine forests of the South as its newest raw material.

The Yale School of Forestry has samples of some 35,000 different woods. Only a relatively few of these have commercial possibilities as pulp woods but with the changing economic and geographical shifts of the industry new wood sources are continually being investigated and pulp processes being modified to accommodate them.

How a Tree Grows

Before discussing the structure of wood, brief consideration will be given the manner of tree growth. The roots, that part of the tree below the ground, absorb water and dissolved mineral matter. When absorbed, this solution, now called sap, travels up through the trunk of the tree in the sapwood, between the heartwood and the bark. Finally, reaching the leaves through the limbs, or crown, the sap is converted into food for the life processes. Carbon dioxide, present in the air, is absorbed through the pores or cells in the leaves. Then, in the presence of chlorophyll, the green coloring matter of plant life, and sunlight, the sap combines with the carbon dioxide forming carbohydrates, chief of which are sugars. The carbohydrates, or food, are carried in solution downward between the sapwood and bark in what is known as the cambium layer. In this layer are cells which take up this food and grow and divide.

It is generally considered that an intermediate compound, trioxymethylene, or formaldehyde, is formed which polymerizes into sugar which is later dehydrated forming cellulose for growth as follows:

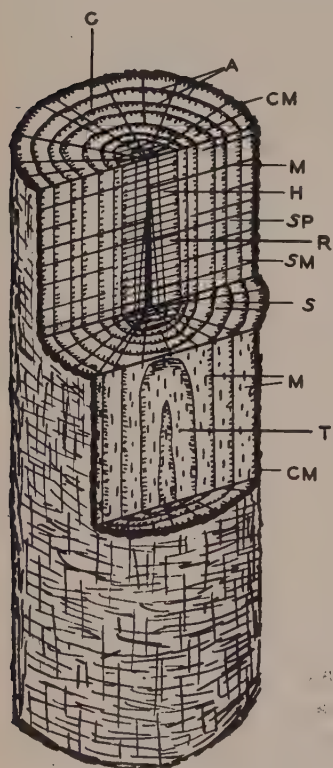


The new cells formed next to the sapwood become wood fibres and those next to the bark, bark fibers. This development, while constant, divides itself into two growing seasons annually. Springwood, formed in the early part of the year, is made up of thin-walled, soft low density fibers. Later, summerwood of thick-walled, harder and more dense fibrous structure, is formed. That this dense darker wood is adjacent to the lighter

springwood is responsible for what are called annual rings. One of these is formed each year. Variations in character of these annual rings are the result of climatic and growing conditions being different from year to year. For each annual ring in the wood, a ring is formed in the bark.

The proportion of springwood increases in a log from the butt to the top. Logs cut midway between butt and top usually produce the best pulp as they have longer fibers, straighter grain and less knots. Top logs show lower yield producing pulps of slightly lower bursting and tearing strength.

On growing, the central portion of the trunk, or heartwood, becomes more or less inactive due to plugging of bordered pits by resins, and serves chiefly as support for the trunk. The sapwood is that part through which the life process is actually carried on. While coniferous and deciduous woods are structurally different the life process is essentially the same. There are many theories as to the detailed mechanism of tree growth, the scope of which is beyond our present consideration. References to more advanced discussion are given in the bibliography at the end of the chapter.



Structure of the Growing Tree

As we are chiefly interested in the tree as a source of papermaking fiber we will confine our consideration of structure to that portion from which it obtained—the trunk. The sections of a tree, which will be later considered in detail, are shown in Fig. 18.

- C—Cross section.
- R—Radial section.
- T—Tangential section.
- A—Annual ring.
- CM—Cambium layer.
- M—Medullary ray.
- H—Heartwood.
- SP—Springwood.
- SM—Summerwood.
- S—Sapwood.

Fig. 18. Section of Tree

On looking at the top, or cross section, of the log can be seen a thick dark layer around the outside. This is the bark. Inside, the light unshaded area is the sapwood. Then, in the center of the trunk is a dark shaded portion, or heartwood. A closer examination shows a number of concentric rings—these are the annual rings.

To more closely examine the structure of the tree it is necessary to cut two more sections. First one along the axis of the log and passing through it. This is known as the radial section. Here can be seen the medullary rays which allow for the sap to pass from one fiber to another radially.

Next, a tangential section is taken parallel to the axis but not passing through it.

In a more detailed examination of the wood sections, Western hemlock will be considered representative of coniferous and cottonwood of deciduous specie. Both of these are used at Camas.

The more salient features can be seen in the photomicrographs in Fig. 19 and 20, according to the following key.

L —middle lamella (bonding or cementing layer between the fibers or tracheids.

Tr—fibers or tracheids.

M —medullary ray.

Sp —springwood.

Sm—summerwood.

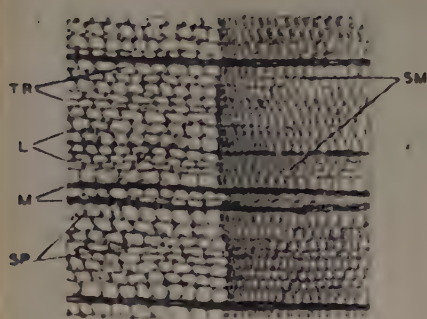
A —annual ring.

Bp—bordered pit (diaphragm openings in radial wall of the tracheid through which the sap passes from one fiber to another, tangentially).

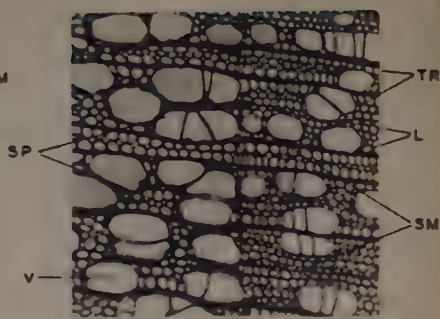
p —simple pits at medullary ray crossing.

V —vessels (in deciduous trees).

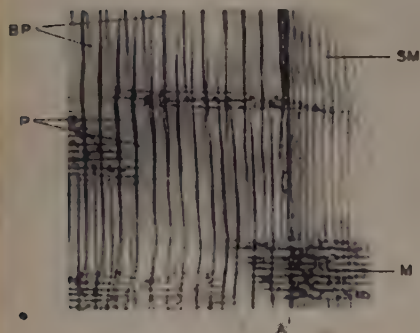
Note that the pits on the fiber walls are only visible on the radial face and generally pronounced on only the springwood fibers. The middle lamella, medullary rays, and vessels in the case of deciduous woods, are almost entirely removed during the cooking process, thus freeing the tracheids or fibers, which, when later meshed on the machine wire, form the sheet of paper. While the ray cells and vessels are of some value in paper making they have insufficient resistance to the cooking chemicals to be found in more than a small percentage in the pulp. Of the cellulose content of the tree these fibers comprise from 10 to 15 percent.



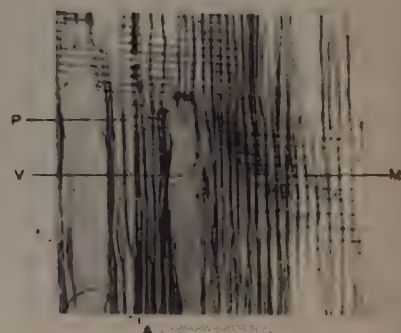
Cross Section



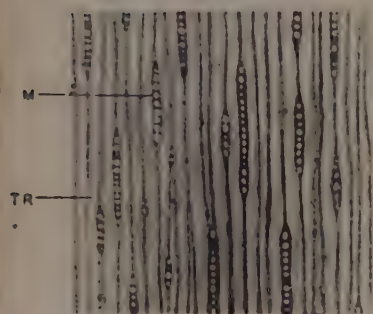
Cross Section



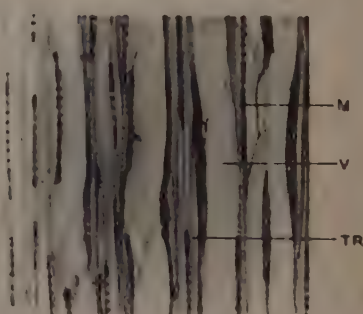
Radial Section



Radial Section



Tangential Section



Tangential Section

Sections of Western Hemlock

Sections of Cottonwood

Fig 19

Wood is not a homogeneous material like glass or steel, but is made up of fibers of widely varying characteristics. While we know that because of this fact one tree differs from another, it is also true within any one tree.

In general, the average length of western hemlock fiber is 2.7 millimetres, or slightly over 1/10 inch, and that of cottonwood about 1.3 mm, or 1/20 inch. In all cases the fibers are, approximately, one hundred times greater in length than width.

Variations of fiber length within any one tree are considerable. In the very center of the trunk the fibers are much shorter than just next to the bark. After about the fiftieth year, however, the length increases but very little. Also, the fiber is of varying length, depending upon its position in the trunk in relation to its distance from the ground. Between 10 and 20 feet above the ground the fiber length is generally longest; above or below that point it is shorter.

Of the many physical properties of wood, our concern is with only a very few. Because of a longer fiber length one particular species may be chosen over another to obtain desired properties of pliability and tearing resistance in the finished paper. Some woods result in pulps of greater brightness and are so selected. Properties of this nature, however, will be considered in following chapters on fiber qualities and under the various pulping processes so will not be further developed here.

Wood Characteristics Affecting Pulping

Density is probably of greatest importance because of its bearing on yield. The yield of pulp produced depends in part on the amount, or density, of wood substance possible to put into a digester. Thus, with equal volumes of hemlock and white fir containing 23.7 and 21.8 pounds oven dry wood per cubic foot, respectively, greater yields can be expected from use of the former.

Density of wood is affected by a great many contributing factors among which are altitude, season of growth, amount of precipitation, latitude in which grown, and local soil conditions. The closer the annual rings are together, the denser the wood. In spruce, for example, wood of 10 to 15 rings per inch weighs 22.4 pounds per cu. ft., while wood of 50 to 60 rings per inch weighs 26.8 pounds.

A block of wood is composed of actual "wood substance," together with considerable air space in and between the fibers. The wood substance weighs approximately 96 pounds per cubic foot so it can be seen that wood normally is mostly air. The actual wood substance weighs about the same in all species and one wood is heavier than another because it contains

less air space. Also, the fact that wood substance is heavier than water means that wood floats simply because of its air content.

Specific heat is of some importance. It is of advantage to cook that wood requiring the lowest steam usage to increase a unit weight of it through unit temperature increase.

Moisture content of wood, present both as free and mechanically bound water in the cell cavities, and bound water within the fiber walls themselves. There is no appreciable effect on fiber properties if the free water is lost. However, removal of bound water is accompanied by a shrinkage and destruction of fiber quality. It is important, then, not to excessively dry out wood if the best pulp is to be obtained. Knowing the moisture content of the wood chips is of value in the cooking process so that a proper balance of actual wood substance and cooking chemicals may be obtained.

The characteristics of wood affecting rate of liquor penetration are very important. The penetration rate in the digester, in addition to being influenced by strength of acid, temperature, pH and pressure, varies with chip size, wood species and density. Penetration is many times more rapid in sapwood than in heartwood. Penetration in the longitudinal direction of the fibers is more rapid than in the transverse direction.

For ready reference some of the properties of Western wood species are shown in the following table.

Kind of Wood	1 Weight	2 Shrinkage	3 Yield		4 Wood	Chips		Lumber	Cord Wood
			Lbs. Bone Dry	Lbs. Air Dry		Cu. Ft. per Ton	Units per Ton		
Kind of Pulp: Sulphite, Easy Bl., Sulphate, Kraft, Mechanical, Groundwood.	Weight/cu. Ft. of Solid Wood Green Volume.	Shrinkage in Vol- ume When dried from Green to Bone Dry.			Quantity of solid Green Wood required for pulp		Green Chips re- quired when settled to density of Digester Charge—2¾ times solid volume.	Lumber required when converted to pulp.	Cords of Wood of 128 cu. ft. gross based on 90 cu. ft. solid.
	Lbs. Bone Dry	% of Green Volume			Cu. Ft. per Ton			Bond Feet per Ton	Cords per Ton
Western Hemlock	23	11.6	10.50	11.66	171.52	471.60	2.35	2059	1.90
	23	11.6	11.0	12.22	163.66	450.00	2.25	1964	1.81
	23	11.6	21.60	24.00	81.70			981	.91
White (Grand) Fir	23	10.6	8.90	9.90	202.02	555.55	2.77	2424	2.13
	23	10.6	11.40	12.66	158.00	434.50	2.17	1896	1.76
	23	10.6	19.50	21.66	92.33			1108	1.02
Sitka Spruce	24	11.2	10.80	12.00	166.66	458.31	2.29	2000	1.85
	24	11.2	11.50	12.77	156.61	430.67	2.15	1879	1.74
	24	11.2	20.40	22.66	88.26			1059	.98
Douglas Fir	28	12.6	8.50	9.44	211.86	582.60	2.91	2542	2.35
	28	12.6	11.70	13.00	153.85	423.08	2.11	1846	1.71
	28	12.6							

Chemical Properties of Wood

It is not considered within the scope of this book to enter into a detailed discussion of the chemical properties of wood. A brief conception of the more important ones, however, will provide a better understanding of the discussion of the pulping processes at Camas.

The approximate chemical composition of coniferous wood is:

Cellulose	50	per cent.
Lignin	30	"
Carbohydrates	16	"
Protein	0.7	"
Resins and fats	3.3	"

In deciduous woods cellulose and lignin contents are generally less and carbohydrates content greater. There is considerable variation in composition throughout any one tree so that a representative analysis is difficult to obtain.

Cellulose, or the fiber portion of the tree, occurs in a number of forms. Alpha-cellulose, the most resistant to chemical attack, comprises the largest percentage.

The hemi-celluloses, or less resistant forms, as well as some of the alpha-cellulose, are attacked during the cooking processes and largely or almost entirely dissolved.

Lignin, the bonding or cementing material holding the fibers together, is the object of removal in the digester so that the fibers may be thus purified and set free. Some lignin is still contained in the pulp, however, the greater amounts being found in the more "raw" pulps. The chemistry of lignin is extremely complex and cannot be even partially discussed here, but is an interesting subject for further study.

The carbohydrate materials consist chiefly of the hemi-celluloses and sugars. These substances, intimately associated with cellulose in the fiber wall, are mainly removed in the cooking process.

Fats and resins are not present in troublesome quantities in Western hemlock or some of the firs. Pine contains the largest percentage among the generally used pulpwoods, followed by spruce. Pitch trouble in pulp and on the paper machine is due to natural wood resins but is not as serious a problem at Camas as it is in Eastern and Southern mills.

This chapter should serve as a general introduction to the subject of wood. Further information will be introduced in some of the chapters to follow. For a more comprehensive study the student is referred to the

bibliography which references are made available in the Laboratory Library.

Acknowledgement is made to the several references, especially, "The Manufacture of Pulp and Paper, Vol. III," from which information was liberally appropriated.

BIBLIOGRAPHY

Books

- Alexander, Jerome: "Colloid Chemistry—Theoretical and Applied," Vol. IV, Technical Applications, 1932, The Chemical Catalog Company.
- Brown, H. P.: "Atlas of the Commercial Woods of the United States," 1928, N. Y. State College of Forestry.
- Cross, C. F., and Bevan, E. J.: "A Text Book of Paper Making," 1936, E. and F. N. Spon, Ltd.
- Roree, Charles: "The Methods of Cellulose Chemistry," 1933, D. Van Nostrand Company.
- Hawley, L. F., and Wise, Louis E.: "The Chemistry of Wood," A. C. E. Monograph No. 28, 1926, The Chemical Catalog Company.
- Hess, Kurt: "Die Chemie der Zellulose und Ihrer Begleiteu," 1928, Akademische Verlagsgesellschaft.
- Herzberg, Wilhelm: "Papierprüfung," 1907, Julius Springer.
- Herzog, Alois: "Mikrochemische Papier—untersuchung," 1935, Julius Springer.
- Heuser, Emil: "Textbook of Cellulose Chemistry," 1924, McGraw-Hill Book Company.
- West, C. J.: "Bibliography of Paper Making," 1928, 1935, 1936 and 1937, Lockwood Trade Journal Company.
- Schorger, A. W.: "The Chemistry of Cellulose and Wood," 1926, McGraw-Hill Book Company.
- TAPPI: "The Manufacture of Pulp and Paper," Vol. III, 1937, McGraw-Hill Book Company.

Bulletins

- Bulletin No. 1485, U. S. Department of Agriculture. "The Suitability of American Woods for Paper Pulp," 1927.
- Tech. Bulletin No. 544, U. S. Dept. of Agric., "Yield of Even Aged Stands of Sitka Spruce and Western Hemlock," 1937.

- Tech. Bulletin No. 201, U. S. Dept. of Agric., "The Yield of Douglas Fir in the Pacific Northwest," 1930.
- Tech. Bulletin No. 566, U. S. Dept. of Agric., "Western Hemlock Bark and Important Potential Tanning Material," 1937.
- "Wood Handbook," 1935, Forest Products Laboratory.
- Free Pamphlet No. 5, Dept. of the Interior, Canada, "Western Hemlock," 1924.
- Forest Service—Bulletin 93, "The Aspens—their growth and management," U. S. Dept. of Agriculture, 1911.
- Tech. Bulletin No. 511, U. S. Dept. of Agric., "Timber Growing and Logging Practice in Ponderosa Pine in the Northwest," 1936.
- Tech. Bulletin No. 479, U. S. Dept. of Agric., "Strength and Related Properties of Woods Grown in the United States," 1935.
- Forest Service—Circular 150, U. S. Dept. of Agric., "Douglas Fir—a study of the Pacific Coast and Rocky Mountain forms," 1909.
- Bulletin No. 55, U. S. Dept. of Agric., "Balsam Fir," 1914.
- Free Pamphlet No. 3, Dept. of the Interior, Canada, "Douglas Fir," 1923.
- Forestry Branch—Bulletin No. 71, Dept. of the Interior, Canada, "Canadian Sitka Spruce—its mechanical and physical properties," 1921.
- Forestry Branch—Bulletin No. 60, Dept. of the Interior, Canada, "Canadian Douglas Fir—its mechanical and physical properties," 1918.

CHAPTER III

PULP AND FIBER QUALITIES

By A. W. NEUBAUER

Of the vast number of fibrous materials which have been proposed for and used in paper making wood is by far the most important. The products of Camas mill are manufactured entirely from wood fibers. Moreover the species used are comparatively few and practically entirely of the softwood group. The present chapter will be confined to the more practical aspects of fiber qualities as related to pulp and papermaking processes and the reader is referred to the literature cited for a more detailed and comprehensive treatment.

Fiber Structure

In the evaluation of fibers for papermaking, it can readily be appreciated that size, shape and inherent properties are of considerable significance. As a general rule for chemical pulps, the coniferous fibers are approximately 3 mm. or 0.12 inches in length, while the deciduous fibers (for example, cottonwood) are roughly 1.3 mm. or 0.05 inches in length. The following table compiled from the literature (13, 24) includes the more important papermaking fibers from woods:

SPECIES	Fiber Length Millimeters	SPECIES	Fiber Length Millimeters
Grand Fir (Lowland White)	3.2	Jack Pine.....	2.5
Amabilis Fir.....	3.1	Loblolly Pine.....	3.0
Balsam Fir.....	2.7	Lodgepole Pine.....	2.3
Noble Fir.....	2.6	Norway Pine.....	3.7
Douglas Fir.....	4.4	Scrub Pine.....	2.8
Western Larch.....	2.6	Longleaf Pine.....	3.7
Sitka Spruce.....	3.5	Black Cottonwood.....	1.3
Engleman Spruce.....	3.0	Eastern Cottonwood.....	1.2
Red Spruce.....	3.7	Aspen.....	1.0
Black Spruce.....	2.6	Black Willow.....	0.8
Eastern Hemlock.....	3.0	Basswood.....	1.2
Western Hemlock.....	2.7	Yellow Birch.....	1.5

Note.—One millimeter equals approximately 1/25 inches.

The type of fiber is dependent on the period in which it develops as well as its function in the wood structure. Springwood fibers are thin-walled while summerwood fibers are thick-walled. Also the surface of springwood

fibers contain more pits than those of summerwood. While the springwood fibers of coniferous pulps appear as collapsed ribbon-like elements, the summerwood fibers, being more rigid, appear somewhat as inflated tubular elements. It is for these reasons that springwood fibers are more readily refined (ruptured, bruised, and frayed) in beaters and jordans.



Fig. 20 Hemlock Fiber showing Simple and Bordered Pits

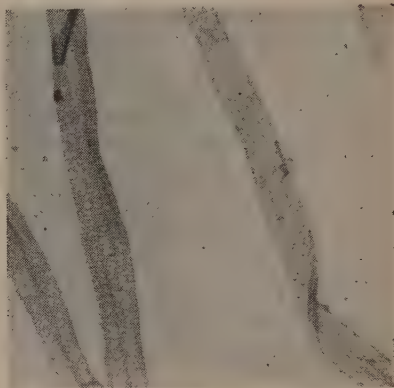


Fig. 21 Douglas Fir Fiber showing Spiral Thickening

Fiber walls often show "patterned" groupings of simple pits known as ray crossings. These are quite valuable in the identification of the wood from which the pulp was produced. Though very evident in the original pulp, these groupings of simple pits are often greatly distorted and almost indistinguishable after severe refining or processing. The fibers of hardwoods, on the contrary, seldom possess any outstanding features which would be of diagnostic value. They are only approximately one-half as long as the coniferous tracheids and are classed according to surface markings, thickness and shape (20). The vessel segments of the hardwoods, however, are used in identification of woods of this group. In view of the fact that these elements are so extremely fragile, it is often not possible to note many whole segments and accordingly the problem of identification becomes more complicated.

In the case of groundwood, more of the actual character of the wood can be recognized. In other words, groundwood consists of pieces of fibers, fiber bundles, and a small amount of wood flour. The particular size, therefore, may be considerably varied depending upon the purpose for which the stock is intended.

Fiber Qualities From Various Woods

The question often arises as to which species can be used to the best

advantage. At Camas, the types of woods used are limited to a few conifers or softwoods (Western hemlock, grand, noble and amabilis fir, Sitka spruce) and but one deciduous or hardwood specie (black cottonwood).

From experience, it is known that a certain species when pulped produces a stock of better bursting resistance (Mullen) than another. For example, under normal conditions of pulping and refining, kraft pulp from hemlock has a higher Mullen strength and lower tearing resistance than when made from Douglas fir. Western hemlock fiber is considered to produce paper of higher folding and tearing strength than many Eastern woods. Likewise, when these woods are ground for newsprint manufacture, the "bulking" characteristics of the local conifers can be rated in the order: firs, spruce, and hemlock. In other words, the firs, when mechanically pulped, yield a fiber which will produce a bulkier sheet than spruce or hemlock.

Recent publications have pointed out that in the case of certain Southern pines, one of the most important factors influencing pulping, and consequently paper qualities, is the ratio of springwood to summerwood (2). This can be understood when it is realized that springwood generally contains more lignin (1 to 5 percent) and is of somewhat different physical structure than summerwood. Likewise investigators (1) have noted that all the strength properties of pulps produced, except tear resistance, are improved with increase in springwood content and that a variation of 10 percent in springwood content in any one species generally results in a greater difference in pulp quality than is exhibited between the different species examined. It has also been demonstrated (3) that the color of unbleached stock becomes higher as the percentage of springwood is increased and that pulps of high summerwood content are coarse, bulky, dark and have a higher bleach requirement. In this connection, Curran (3) has stated that in all species, springwood fibers are more thin-walled and flexible than summerwood fibers and that this is reflected in the nature of the pulp, especially in the surface and character of the sheet produced therefrom. This he explains by the fact that the thin-walled springwood tracheids collapse to ribbon-like fibers forming dense, well-knit sheets whereas the stiff thick-walled summerwood fibers tend to remain in tubular form, resisting processing and forming coarse-textured sheets.

It is the general consensus of opinion that abnormalities in growth and in growth conditions are often responsible for variation in pulp and consequently in the paper. This has been recognized at Camas in that not much variation in chemical pulp quality can be detected in the use of the several firs (which are generally grouped and given the misnomer, "White Fir"). On the other hand, the firs from one region yield a more desirable

stock than those from another.

Perhaps the most significant type of abnormal growth is compression wood. This is evident whenever growth occurs under a condition of stress, for example, in leaning trees, on the underside of limbs, and in trees of eccentric growth. Compression wood differs markedly from normal wood (3) in chemical composition, and in physical and pulping qualities. The yield from compression wood is lower and the pulp is weaker and of higher bleach requirement. In the case of groundwood, it has been found (4) that the presence of compression wood has a deleterious effect on the pulp produced especially in regard to strength. This is explained by the fact that on grinding under the same conditions, compression wood yields greater amounts of small fiber fragments than normal wood.

Fiber Qualities Affected by Pulping Methods

Although of late a considerable number of new types of pulps have made their appearance, Camas mill produces only the "basic" pulps—kraft, sulphite and groundwood.

Johansson (22) has stated that the chemical composition does not entirely control strength and other properties of a sheet made from fibers. For example, although the spring and summerwood fibers are of comparable composition, the ratio of one to the other has a marked effect on the properties of the paper made from varying proportions of the two (2). On the other hand, assuming sulphite pulps produced from the same raw materials, the tensile and Mullen strengths increase with the chlorine number whereas the tear resistance decreases gradually (22). Also for krafts produced from the same wood (22) the tensile and Mullen strength rise markedly with increase of chlorine number as does the beating time to a standard degree. As a general rule, the darker the color of kraft stocks, the higher the chlorine number.

Groundwood is manufactured purely by mechanical means, by the abrasive action of a revolving stone on a block of wood, and thus contains all the wood substance except such components as are water soluble. The manufacture of chemical pulp, however, is effected by removing from the wood a large part of the lignin and other non-cellulosic substances. The actual character of groundwood in regard to proportions of fiber bundles, wood flour, fiber, fragments, etc., depends entirely on grinder pressure, temperature, stone grit, jig pattern and other grinder variables.

Mechanical pulp or groundwood is used primarily as an adulterant fiber as well as to obtain certain paper properties, since it is the cheapest pulp obtainable. Newsprint, the largest outlet for this stock, contains 80 to 100 percent groundwood. It is also one of the major constituents of such

sheets as rotogravure, carbonizing, cheap books and manilas, certain wrappings, building papers, board, etc. Especially in the case of news-print manufacture, refining equipment such as beaters and jordans are being used to a lesser extent and for that reason it is necessary that the correct type of fiber be produced at the grinders.

There are many types of groundwood ranging from the long highly-fibrillated to the short, chunky stock. For this reason groundwood cannot be specified by freeness or strength alone but must be defined by both. Highly fibrillated stock is attended by poor formation characteristics but good strength, whereas the opposite is the case for smooth stubby fibers. The dense smooth sheets manufactured from fine pulps are less opaque to light and less receptive to printing inks than are the bulkier pulps. It is claimed that seasoned wood yields a groundwood which will form a more opaque sheet than a similar stock from green wood. The practice of steaming the pulp wood prior to grinding is not followed at Camas. In this case, a stronger but darker pulp results.

In general the color of mechanical stock closely resembles that of the wood. For economic reasons, it is not feasible to bleach mechanical pulp. Of late, however, it has become the practice to "brighten up" groundwood with such agents as zinc hydrosulphite and sodium bisulphite. Considerable variation in brightness also can be noted by changing the acidity or pH. For example, the pulp may be of satisfactory brightness when the pH is maintained at 4.5-5.0, but for some reason should the pH be raised to 6.5-7.0 (practically neutral) the stock would be very noticeably duller. Also in this connection, some sheets containing a fairly high groundwood content (for example, towel stock) show a definite and often undesirable auto-sizing if the paper is manufactured under too acid conditions and the groundwood is produced from one of the more resinous woods. In such a case, it is sometimes advisable to sacrifice color to some extent by maintaining a machine white water pH close to neutral.

Kraft pulp, as the name implies, is characterized by its strength. Its origin is practically entirely from coniferous woods. This method of pulping removed cementing and incrusting portions of the fibers with less injury (minimum hydrolysis) to the fiber (cellulose) itself than acid pulping. Also the addition of sodium sulphide (the distinguishing feature of kraft over soda cooking) diminishes the deleterious effect of more active alkali and favors a higher retention of the inherent fiber strength (9).

Sulphite pulp, like kraft, is manufactured by a chemical process though in this instance the active liquor is acidic in nature and the lignin is dissolved by conversion into lignin-sulphonic acids whose calcium salts are soluble. Sulphite is characterized by fair brightness and moderate strength.

At Camas, the woods used for this pulp are generally one of the several firs, hemlock and occasionally spruce. Sulphite is a utility fiber which finds adaptability and success in many fields. Sulphite bleaches quite readily to a good white color, and by following certain precautions, the bleached stock retains practically all the strength properties of the parent unbleached pulp. Its use is increasing both as partial and entire furnishes, particularly since the tendency has been toward brighter sheets and the level of sulphite strength has been raised materially by improved pulping methods.

Of late, the use of cottonwood sulphite has made its appearance. This sulphite of deciduous origin is generally always bleached and as such gives very good brightness. Its shorter fiber length naturally is accompanied by a lower strength than sulphite from conifers. In certain instances it may be used as a substitute for soda pulp, although it is claimed that it possesses less softness and bulking quality. It is readily hydrated. At Camas the cottonwood is generally cooked quite soft, then bleached and furnished when a soft sheet is desired (as in certain toilet tissues, towels, etc.) or in a furnish necessitating a filler fiber (envelope).

Among the pulps not produced at Camas, soda pulp is one of the more important. This is usually of deciduous wood origin, though some samples have been examined which contained portions of coniferous fiber. In most instances, poplars (of which aspen and cottonwood are species) are pulped by the soda process. This type of pulp is more of a specialty fiber and is generally used in book, envelope, etc. Soda pulp tends to make the sheet softer and improves the printability by providing a smooth surface or texture and a "cushioning" action in printing presses. Unrefined soda pulp is freer than deciduous sulphite and is less easily hydrated (9). On the other hand, its brightness is generally lower than that obtained with bleached hardwood sulphite.

Less frequently encountered are the alkaline sulphite stocks, such as Keebra, Sodite, and the like. Such stocks are generally pulped from coniferous woods and possess good strength properties comparable to those of the bleached krafts.

Within the last decade, "alpha" pulps have been developed which possess characteristics suitable for certain special requirements. It is claimed (9) that "alpha" fiber produced from coniferous woods has the tear resistant qualities of kraft, the softness of rag and a color even exceeding bleached sulphites. As designated by the name, these pulps have a high alpha-cellulose content and accordingly seem to possess permanence comparable to rag stock. High alpha-cellulose fibers from deciduous woods (9) are outstanding for softness and absorbency. They are generally used as a part furnish where opacity, bulk, and good formation are desired.

For those interested in a more detailed discussion on the effect of digestion on wood structure, the recent publication by Bixler (10) and the references cited in the article will prove very enlightening. This information is available in the laboratory library.

Fiber Qualities Affected by Refining

By refining is meant the mechanical action to which a pulp suspension is subjected preparatory to formation into the sheet. Various types of machines have been developed for this purpose and each has a somewhat different action on the pulp.

Wicker (11) has summarized the changes which are effected upon the fibers under the headings: Gelatinization or swelling, fibrillation, and reduction in fiber length. Gelatinization, a chemico-physical change, is characterized by a slippery feel of the stock and a marked shrinkage on drying. Highly gelatinized or "hydrated" stock forms a very dense sheet of high bursting strength. Fibrillation is a mechanical alteration of the fiber causing the fibrillae or "whiskers" to separate to some extent in a manner comparable to an individual fiber separating from a piece of yarn when the latter is exposed to mechanical treatment. This change is accredited with increasing the bonding between fibers as well as influencing sheet formation. The effect is one of exposing greater fiber surface by opening up the fibrils which are spirally arranged around the fiber. On the outside the fibrils are nearly at right angles to the fiber axis and become more nearly parallel to the major axis near the center of the fiber. Reduction in fiber length is another purely mechanical action. Its purpose is primarily as an aid in sheet formation by the production of short or fragmentary elements which are desirable in filling the voids between the larger fibers of the sheet.

The degree of refining is often measured in terms of freeness. From a practical or control viewpoint the freeness figure is of considerable value in that it enables duplication of machine settings from one run to another. On the other hand, freeness does not define the character of the stock other than its draining qualities when the pulp suspension is put on the wire. A stock may be "slow" because it is hydrated, because it is short-fibered, or due to a combination of these two factors.

As stated previously, it is claimed (6) that springwood fibers are more easily ruptured and frayed than are summerwood fibers. Accordingly, variations in wood will ultimately be noted in the refining processes. Experience with Camas pulps has demonstrated that kraft stock requires at least twice the power required for sulphite to reduce the freeness the same amount. In other words, each type of fiber, depending on the hard-

ness of the cook and subsequent processing, will require a different amount of power for refining, the highest requirement being that for unbleached kraft and the lowest for a bleached sulphite. As a matter of fact, a soft bleached cottonwood "hydrates" noticeably merely on circulating in a beater whose roll is raised, or even as a result of pumping.

In general all stocks darken and form more transparent sheets when beaten according to the practices for wet beating. For example sulphite, which is of moderate strength and easily hydrated, especially when undried, may be beaten with suitable tackle to yield good grease-proof or glassine stock. On the other hand, when beaten or jordaned at a rather low consistency and with a sharp tackle, sulphite yields a sheet having fair opacity and formation. In no case, however, does coniferous sulphite exceed soda pulp or even deciduous sulphite as a fiber which renders surface smoothness, bulking qualities and opacity to the sheet.

Figures 22 and 23 show the effect of refining on fiber structure.

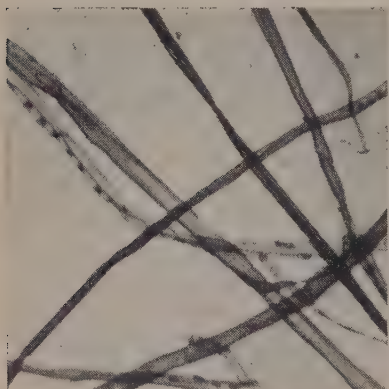


Fig. 22 Free Stock

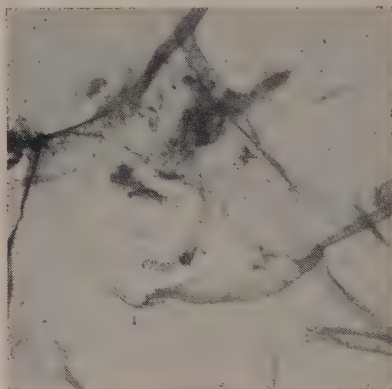


Fig. 23 Well Hydrated Stock

As might be inferred from foregoing considerations, the problem of manufacturing a specific sheet of paper may resolve itself into quite a scientific operation in which knowledge of the structural units is essential (12). The individual fibers in the web may be termed the units and the structure of the sheet may be dependent on such factors as formation, fiber alignment in relation to the principal axis of the sheet, and sheet density. The papermaker recognizes that the more highly hydrated the stock is, the smaller the fiber particle size, and the greater the pressure applied in the wet condition, the more dense will be the resulting sheet. Also, the ability to remove water from any stock is always less for "slow" than for "free" pulps. That is, a "free" stock drains and presses easier

than a "slow" pulp. Then too, there is a critical point up to which certain stocks may be refined. At this value, a given quality (for example, Mullen strength) will be at the maximum whereas if not attained or if refined past this point, the fiber will not display its maximum value. In this connection it might be mentioned that all pulps on being dried lose their ultimate bursting strength, that is, the maximum Mullen of pulp which has been dried will be less than that of the original slush stock. For this reason it is not possible to manufacture a given paper of as high a Mullen value with dried pulp as could be produced with the same stock before it had been dehydrated (23).



Fig. 24 Pine Fibers showing Characteristic Pits

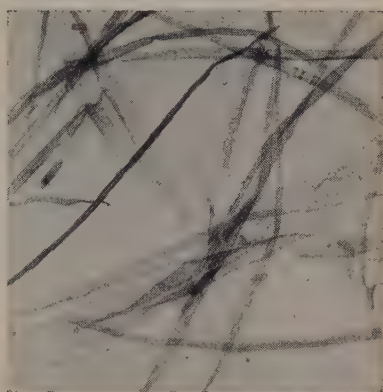


Fig. 25 Cottonwood Pulp showing Fibers and Vessels

Fiber Identification

Microscopical examination of fibers is an important phase of fiber study. Its primary application includes such fields as examination of paper furnishes and studies in pulping, bleaching and refining. Considerable material has been compiled on the microscopy of paper (as evidenced by Calkin's bibliography (14)) but for the present purpose, only some of the more essential facts and references will be given.

In the first place, it is necessary that the microscopist have a thorough training in wood technology and fiber morphology (17) along with an understanding of the various types of fibers that are used to produce certain sheet characteristics. Also, he must be thoroughly familiar with the microscope, its optical system and accessories. One of the best works on this subject is that of Chamot and Mason (19) and it is recommended that the reader refer to this book should he anticipate work in the field of microscopy.

Quite recently Harrar and Lodewick (20) have prepared directions for identifying woods and wood fibers on the basis of their structure. This work which has supplemented and been adopted from previous articles (7) by these authors, includes three keys: (1) the American woods used for pulp and paper; (2) pulpwood fibers of Western United States, and (3) pulpwood fibers of Eastern United States. Appended thereto are descriptions of American pulpwoods dealing with both gross and minute features. Also the reader will find the atlas prepared by Carpenter (8) of considerable assistance.

Along with a recognition of fiber morphology, the fiber analyst must resort to certain stain reactions to ultimately determine by which process the wood was pulped. Of the older stains, the Herzberg, Sutermeister, Lofton-Meritt and Bright stains (21) are the more commonly used. Their scope, however, has been somewhat limited in that differentiation of some of the newer types of fibers is not possible, for example, bleached kraft, "alpha" fibers, etc. More recently, Graff (16, 17) has developed a series of stains with which the microscopist can distinguish all the fibers heretofore recognized with the older stains and in addition the newer fibers. The reader, however, should be cautioned that to insure reliable results, it is necessary to have considerable training and practice in their use.

Facilities for Study

The laboratory maintains a completely equipped dark room where permanent records in the form of photomicrographs are made. Various stains and methods of illumination are often used to accentuate a particular characteristic. Several microscopes are available for these studies along with many useful auxiliary accessories. Research on fiber qualities is being conducted continually in an endeavor to extend our knowledge of our most important raw material and interpret these studies into improved pulping and papermaking practice.

REFERENCES

- (1) Chidester, G. H., McGovern, J. N., and McNaughton, G. C., Tech. Assn. Papers, Series 21, p. 264-7 (1938).
- (2) Bray, M. W., and Curran, C. E., Tech. Assn. Papers, Series 20, p. 458-65 (1938).

- (3) Curran, C. E., Tech. Assn. Papers, Series 20, p. 464-8 (1937).
- (4) Pillow, M. Y., Schaefer, E. R., and Pew, J. C., Tech. Assn. Papers, Series 19, p. 178-80 (1936).
- (5) Schaefer, E. R., Pew, J. C., and Curran, C. E., Tech. Assn. Papers, Series 21, p. 449-56 (1938).
- (6) Ritter, G. J., Tech. Assn. Papers, Series 19, p. 435-43 (1936).
- (7) Harrar, E. S., and Lodewick, J. E., Paper Ind. 15: 630-37; 16: 103-11, 327-35 (1934).
- (8) Carpenter, C. H., "Atlas of Paper-Making Fibers," New York State College of Forestry (Syracuse), Technical Bulletin No. 35 (October, 1931).
- (9) Richter, G. A., Tech. Assn. Papers, Series 19, p. 447-51 (1936).
- (10) Bixler, A. L. M., Tech. Assn. Papers, Series 21, p. 181-192 (1938).
- (11) Wicker, D. B., Tech. Assn. Papers, Series 20, p. 153-9 (1937).
- (12) Doughty, R. H., Tech. Assn. Papers, Series 19, p. 454-6 (1936).
- (13) Wells, S. D., and Rue, J. D., The Suitability of American Woods for Paper Pulp. U. S. Department of Agriculture, Bulletin No. 1485 (1927).
- (14) Calkin, J. B., "Microscopy of Paper". TAPPI Specia' Bibliography Series, No. 1 (1937).
- (15) Graff, J. H., Tech. Assn. Papers, Series 18, p. 197-211 (1935).
- (16) Graff, J. H., Tech. Assn. Papers, Series 18, p. 293-8 (1935).
- (17) Graff, J. H., Tech. Assn. Papers, Series 19, p. 305-8 (1936).
- (18) Report of Fiber Identification Symposium, Tech. Assn. Papers, Series 20, p. 349-58 (1937).
- (19) Chamot, E. M., and Mason, C. W., "Handbook of Chemical Microscopy," Vol. 1, John Wiley and Sons, New York (1931).
- (20) TAPPI Method. T 8 sm-37.
- (21) TAPPI Method. T 401 M.
- (22) Johansson, D., Tech. Assn. Papers, Series 19, p. 431-4 (1936).
- (23) Doughty, R. H., Tech. Assn. Papers, Series 16, p. 460-7 (1933), et ante.
- (24) Kress, et al, "Suitability of Various Species of Wood for Pulp and Paper," U. S. Department of Agriculture; Forest Products Laboratory; reprinted from Paper, July 30, 1919.

- (25) "The Manufacture of Pulp and Paper," Vol. III, prepared under the direction of the Joint Executive Committee on Vocational Education representing the Pulp and Paper Industries of the United States and Canada, McGraw-Hill, New York (1937).
- (26) Sutermeister, E., "The Chemistry of Pulp and Paper Making." John Wiley and Sons, New York (1920).
- (27) Matthews, J. M., "The Textile Fibers," Fourth Edition, John Wiley and Sons, New York (1924).

CHAPTER IV

WOOD PREPARATION

By HERMAN JUNG

PART I—SAWMILL

Recent Improvements

The equipment and methods of cleaning and preparing wood at Camas have been greatly improved since 1930. Prior to that time the wood mill consisted of eight vertical steam splitters, three drag saws and one cut-off saw with barking equipment consisting of one drum barker and eighteen disc barkers.

In 1930 the present modern sawmill was erected replacing the old splitter mill. A second barking drum was installed replacing most of the disc barkers, keeping only enough to remove the black knots and bark seams.

In 1934 a third drum barker was added to keep pace with increased output. In the same year the log haul and log lift were replaced by more modern and efficient equipment. This further increased the hourly capacity of the sawmill necessitating adding a fourth drum barker. In making these improvements, primary consideration was given to maintaining a smooth flow of clean wood to the chippers, doing this economically with a minimum of waste and without lost motion.

Species of Wood Used

The annual consumption of wood at Camas is about 126 million feet. Approximately 90 percent of this is hemlock. The paper industry in the Northwest is fortunately located close to large stands of hemlock timber which is more suitable for pulp than for the lumber market. The remaining 10 percent of the wood used is fir, spruce and cottonwood.

The firs species used, grand, noble and amabilis fir, are not particularly suited for lumber but constitute a satisfactory raw material for the kraft, sulphite and groundwood mills. In the case of kraft and sulphite, the yield of pulp per thousand feet of logs is lower than with hemlock. This apparent disadvantage is largely offset, however, by lower consumption of chemicals.

Spruce is used principally in the groundwood mill giving a high grade pulp of excellent color. In practice, it is desirable to divert the outside cuts of the log to the kraft mill, sending the heartwood to the grinders. The quality of spruce logged in this part of the country varies considerably. In some localities we find clear sound wood in nice smooth logs, while in

others the trees are overripe. Overripe spruce is more troublesome to handle, shows a lower yield and produces a pulp of lower color than wood in the proper stage of maturity.

Cottonwood is used both in the groundwood and sulphite mills producing pulps of good color and imparting the necessary softness for certain grades of pulp.

The segregation of logs is in general taken care of by the logging camps, particularly our own camps. However, any raft delivered to Camas with different species in it is sorted before cutting.

Log Characteristics

Texture in hemlock logs varies considerably. This variation is noticed in sawing the log and is felt more or less right through to the pulping processes. This condition might be termed "hard and soft" hemlock or "long and short" texture. Hard hemlock occurs mostly in slow growing trees and those which usually grow in rough and hilly country. Such logs are not always the largest logs. The ground in which these trees grow is not a very heavy soil and this, together with certain climatic conditions, produces slower growth and results in wood of a hard texture.

The other extreme is where the tree grows more rapidly, maturing in a shorter period of time, and yielding wood of a softer and shorter texture. This class of timber becomes overripe much earlier and the heart of the tree becomes softer and starts rotting soon after reaching maturity. Slower growing trees will, of course, often show rotten hearts, but the condition develops much more slowly.

The technical department and pulp mills are notified promptly when overripe logs show up at the sawmill to enable them to be properly prepared to meet the condition.

Wood Measurement

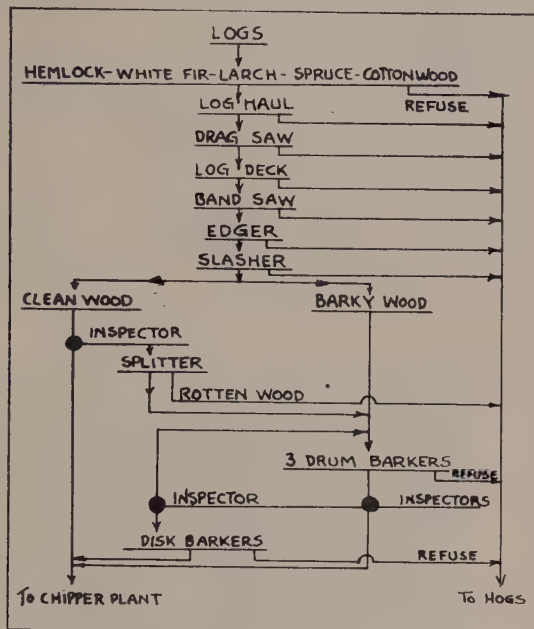
The pulp and paper industry is different from most major chemical industries in the respect that its products are sold mostly by weight, yet its principal raw material is measured by volume.

About forty-five different rules have been devised in the United States for measuring log volume and computing the wood content. On the Pacific Coast the Spaulding Scale and Scribner Decimal C Rule are generally used. These figure log volumes in terms of board feet of lumber produced. A board foot is a volume of lumber one inch thick, twelve inches wide and twelve inches long, equal to 1/12 cubic feet. These scales are meant to designate a thousand board feet of lumber obtainable from a thousand feet of logs.

Following a Log Through the Mill

Fig. 26 shows a flowsheet depicting the course of a log in being broken down into a form suitable for chipping or grinding.

Fig. 26
Flow Sheet of
Sawmill



Logs used at Camas are towed 50 to 100 miles upstream from the lower Columbia River. Rafts are about 700 feet long and about 60 feet wide and will contain from 150,000 to 300,000 feet of logs. On arrival at Camas these rafts are placed in storage in nearby sheltered locations. By means of tug boats the species required are drawn from storage and towed to the log slip where they are attached to donkey cables so that, as the raft is being used, it is being pulled up to make it easier to work the logs onto the haul.

Log Haul

The log haul pulls the logs out of the water by means of a heavy link chain with $1\frac{3}{4}$ " x 10" links operated by a 100 H.P. motor through a 15 to 1 ratio speed reducer. The chain has a linear speed of 95 feet per minute and as the log is being carried up it passes through a series of high pressure sprays to wash off any accumulated or imbedded grit, sand or mud. The log haul raises the log to the saw floor level.

Drag Saw

The logs as received vary from 16 to 90 feet in length and from one

to six feet in diameter. Since 32 feet is the maximum length the log carriage is able to handle, any logs exceeding this are first cut by means of a drag saw. This saw is a 5 gauge saw with a blade 10 feet long and 16 inches wide. It is powered by a 15 H.P. motor and when sharp is able to cut through a 3 foot log in 30 seconds.

Log Deck

After being cut to length, the logs drop onto a short log haul inside the sawmill where they are transferred to the log deck by punch bars operated by a 16" x 36" steam cylinder.

The log deck has room for about 10 logs so acts as a storage point to compensate for short interruptions in subsequent operations. Heavy transfer chains move the log ahead into what is known as a log loader. This is actuated by a steam cylinder and rolls the log to the deck skids in front of the carriage where it is pushed onto the carriage by steam niggers.



Fig. 27 Band Saw

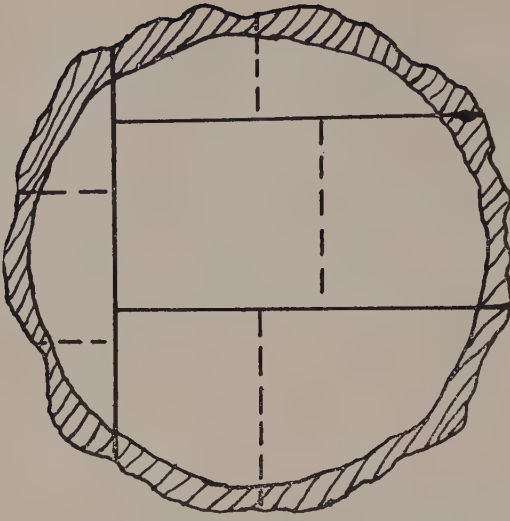
Log Carriage—Sawing the Log

The 60 inch opening carriage is mounted on 80 pound rails and moves the log forward through the saw, backing up with a quick return motion for the next cut. The carriage has an electrically operated automatic set which holds the log firmly in place and regulates the size of the cant sawed off. The log is taper sawed in order to obtain the maximum amount of inside wood free from bark. This is done by a taper attachment which sets the smaller end of the log out so that the bark surface is parallel to the cutting line of the saw. This enables the sawyer to take off slabs of uniform thickness. Small logs are sawed up "alive," that is, logs up to 20 inches in diameter are split through the center and the halves ripped in two by the edger.

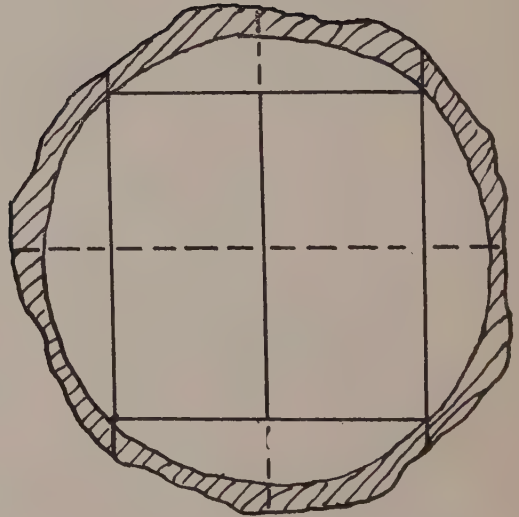
The method of sawing is varied somewhat depending upon the time of year when the logs were fallen. In the winter the bark is tight and in spring and early summer when the sap is up, the bark is usually loose. Tight bark logs, as well as logs with bark seams, require more squaring up in sawing than loose bark logs.

The head rig described is known as a single cut band saw. At one time approximately 20 percent of the sawmills in the United States were using double cut band saws. This method is still used on small diameter logs where the two cuts, made simultaneously, are sufficient to break the log down in a form suitable for edgers and slashers. However, a double cut head rig is not suitable for operations at Camas where large logs are cut to the best advantage by sawing tapered cants, turning the log on the carriage in so doing. Also, a single cut band saw allows the carriage to be returned faster since the log can be offset to clear the saw on its return trip.

Fig. 28 illustrates the variation in percentage of clear inside wood it is possible to secure by varying the sawing. With logs 26 inches or larger in diameter, the log is slabbed on four sides, producing 61 percent inside wood free from bark. When the log is cut up alive only 27 percent inside wood is obtained. Squaring the log, however, naturally slows up the head rig operation as the log requires more turning. The nine-foot band saw has a 15-inch face and can slab logs up to 90 inches diameter and will center-split logs up to 58 inches in diameter. This saw can handle 50,000 board feet per hour.



9 CANTS
27% INSIDE
WOOD



12 CANTS
61% INSIDE
WOOD

Fig 28

Edger

Sawed cants are kicked off the carriage and transferred on live rolls to the edger chain which carries them through the edger saws at 400 feet per minute. The edger rips the cants into pieces with a maximum width of 12 inches, suitable in size for grinding or chipper spouts. The four saws in the edger are each 36 inches in diameter and can be moved by a power shifting device to any width from 4 to 12 inches. Power is supplied by a 300 H.P. motor.

Saw Kerf

In this sawing operation, as well as with the slasher saws, an economical balance is established between a thin circular saw with a minimum kerf loss on one hand, and permissible peripheral speed on the other. In the case of the band saw in the head rig the matter of kerf losses is equally important. A band saw takes about a $\frac{3}{16}$ to $\frac{1}{4}$ inch kerf, considerably less than circular saws which take about a $\frac{1}{2}$ inch kerf. On the basis of three cuts through the log, this difference in kerf would be equal to a board the length and width of the log and $\frac{3}{4}$ inches thick.

Band Edger

The latest improvement replacing the edger is a twin band edger. This machine has two 6-foot band mills. These are placed opposite each other and set up on a heavy frame so the outside band mill can be moved in and out giving the same results as are obtained by the movable edger saws.

By using a twin band edger instead of a circular edger saw in breaking down cants to a maximum width of 12 inches there is a decided saving in saw kerf in that the circular edger saws have $\frac{3}{8}$ inch kerf where the band saw kerf would only be $\frac{5}{32}$, which is $\frac{7}{32}$ inches less, or the equivalent of .0182 feet.

On a general run of logs from 16 to 48 feet this would represent a saving of approximately 1.53 percent.

Slasher and Trimmer

The log is now in the form of long narrow cants and must be cut to lengths suitable for handling. This is done by a series of slasher and trimmer circular saws, each having light 44 inch saws set at 2-foot centers. In the first group of 8 saws, the slasher section, the saws are stationary but the trimmer saws can be raised or lowered individually by compressed air. This arrangement avoids undersize blocks which might give trouble in turning over in the chipper spout.

After passing the slasher and trimmer saws, the blocks fall on a separator apron which diverts clean inside wood to one conveyor and barky wood to a separate conveyor feeding the barking drums.

An inspector watches the clean wood conveyor and any piece showing rot or bark seams have the defective part split off with a steam splitter, returning the good pieces to the conveyor.

Barking the Wood

The barky wood conveyor delivers the wood to the drum barkers. There are four of these, each 10 feet in diameter and 30 feet long. They are operated by 150 H.P. motors and rotate at 8 revolutions per minute. The blocks entering at one end crowd the wood through where it is discharged to a chain conveyor at the opposite end. About 12 minutes is required for a block to go through. The tumbling action in the drum rubs off the bark which is washed out through slots in the drum frame by four nozzles at 50 pound water pressure.

Drum barking has some disadvantages in the respect that the ends of the blocks have a tendency to "broom" and particles of bark may be driven into the broomed ends and carried through to the pulp units with the chip, unless the operation is carefully controlled. Also, drum barking will not completely clean pieces of very irregular shape or pieces with ingrown bark seams. For this reason there are inspectors stationed at the discharge conveyor who pull out incompletely barked pieces and either send them through the drum again or divert them to disc barkers or splitters, depending on their condition. The disc barkers have 60-inch discs each with four knives and are belt driven at 600 R.P.M.

Drum barkers have the advantage of being able to quickly and economically remove the bark without wasting sound wood as is the case with disc barking systems.

One of the newer types of barkers is the Stetson-Ross Log Section Barking Machine. The cutter head on this machine is concave and is equipped with three revolving sets of knives operated by a 50 H.P. motor at 3600 R.P.M. The feeding arrangement consists of two sets of rolls, arranged to form a V-trough and which can be shifted to change the position of the quarter sawed log section or cant in relation to the cutter head. The cutter head can be raised or lowered, swung in a circle or moved horizontally.

This type of barker is very flexible and fast. It has a high speed reversing arrangement whereby the operator can quickly run the cant back through the knives again if incompletely barked the first time.

Many sawmills use various types of knot borers or routers to remove

black knots and bark seams. The bit is specially designed to operate at high speed, usually about 10,000 R.P.M., and its angle can be adjusted to provide for flexible operation.

From this description it is seen that there are two streams of wood leaving the sawmill, one stream of clean inside wood directly from the slashers and the other from the drum and disc barkers. These streams dump into an inclined conveyor which raises them to the head of the flume, leading to the chippers and groundwood mill. This flume is a quarter of a mile long and the tumbling and washing action the blocks receive on their journey gives them a final thorough cleaning.

Waste Wood

The mill is, of course, more interested in the pulp value than in the fuel value of wood. The handling of waste wood and bark and its delivery to the steam plant in a form suitable for use in the boilers is nevertheless an important phase of wood preparation.

Wood refuse from various points in the sawmill is passed through hogs to reduce oversize and produce hog fuel with a reasonably uniform burning rate. There are two hogs, one of which is a 60-inch knife hog direct connected to a 200 H.P. motor operating at 600 R.P.M. and the other a hammer hog operating at 900 R.P.M.

Hog fuel is stored in piles in the mill yard, partly to season the fuel and partly to assure the steam plant of a steady supply since the sawmill does not operate full time as does the steam plant.

A "unit" of hog fuel or chips is equal to 200 cubic feet.

Wood Bunkers

The latest improvement in the sawmill has been the installation of four special wood bunkers. Each of these bunkers is fed by its own conveyor and is used for storing specially selected wood. This selected wood is picked out of both the clear inside wood conveyor and the barked wood conveyor. Only clear pieces with possibly a few small red knots are picked out—no black knots or large red knots are accepted. This means that the bunkers will have a mixture of sapwood and inside heartwood roughly in the same proportion as in the regular run and consequently can be pulped with the same cooking schedule.

In this manner some 45,000 feet of selected wood can be accumulated. This wood is run through the chipper plant separately and is cooked separately in the sulphite mill for special grades of pulp.

Thus the log has been followed all the way through the sawmill. The wood is now in cants about 2 feet long and some 12 inches square, cleaned free of bark and ready for the grinders or the chipper plant.

PART 2.—CHIPPER PLANT

The flow of wood through the chipper plant is shown in Fig. 30, this being the conventional arrangement of chipping and screening equipment. The type and arrangement of this equipment is controlled mostly by the necessity for producing the highest percentage of chips in the desired size range with proper disposition of the undersize and oversize. Careful study has been given to chipper speeds, knife bevel and setting, spout angles and screen sizes and operation to accomplish this.

Chippers

Wood from the sawmill flume is picked up on an inclined conveyor and delivered to the chain conveyor located about twelve feet above the chippers. From this point the blocks are fed into the chutes and the chips produced carried by a bucket elevator to the screening units. Any pieces showing bark that might have gotten by the inspectors at the sawmill are kicked to one side to be later hand barked and returned to the system.



Fig. 29
Chipper with Hood Removed

Fig. 29 illustrates one of the chippers with the spout opened up and the hood off. The disc with one of the knives is shown, also the pins that break up "cards" or clusters of chips as they pass through the knife opening. The wood can be seen in the spout which gives some idea of the angle at which the blocks are fed to the chipper.

The Camas plant includes six chippers, four having 84-inch discs and two with 88-inch discs. The discs rotate at 270 R.P.M. Each chipper has three knives $22\frac{7}{8}$ inches long which are recessed in the disc with the blade projecting sufficiently to cut the desired size of chip. If $\frac{3}{4}$ -inch chips are

desired the knife is set so that there is about one-half inch of the blade projecting from the face of the disc.

While the best size of chip is still a matter of controversy among pulp and paper men, the importance of uniformity of chips is well recognized and the ultimate aim is to produce as high a percentage as possible of whatever size chip has been found to produce the best quality of pulp and the most efficient pulping operation.

Besides the above described knives, the chipper also has a bed knife or plate fastened to the bottom of the spout. This knife is arranged so that it can be adjusted in relation to the disc knives and in practice it is cus-

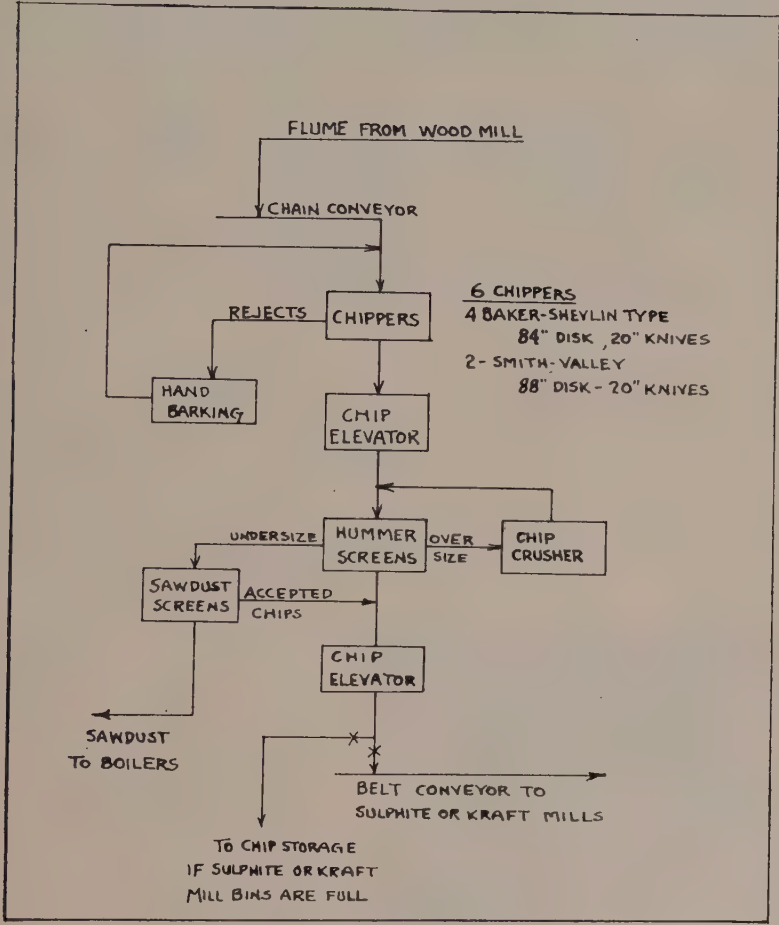


Fig. 30 Flow Sheet of Chipper Plant

tomary to carry about 0.015" clearance between the bed knife or plate and chipper knives.

The proper selection, grinding and setting of knives is extremely important in making good uniform chips. The performance of chipper knives is affected by many factors among which are the grade of steel, its temper and relative hardness between cutting face and the rest of the metal, the way it is ground, bevel of edge, angle with the disc, speed of disc and effect of vibration. A slightly softer temper is used in chipper knives on the Pacific Coast than in Eastern wood rooms as western hemlock has a greater variation in hardness between clear wood and knots than spruce. A single bevel is generally used on the knives; this requires a little more power than a double bevel but gives a better chip. The cutting edge has an angle of about 38 degrees. It is important to keep the bed knives sharp and keep end play out of the chipper shaft to secure a uniform cutting action.

The speed of the chippers has been worked out carefully. There is no general rule to follow as the most efficient speed will vary with changes in spout angle and knife settings.

The spouts on the Camas chippers were originally at an angle of 45 degrees with the horizontal. This is more or less universal practice. However, the chippers have recently been equipped with spouts set at an angle of 52 degrees and better results have been obtained.

Chip Screens

The chips drop from the chipper to a belt conveyor discharging into a bucket elevator which drops them over a distributor onto the screening surface. Seven 4 x 5-foot tandem hammer electric vibrator screens separate the oversize chips and the sawdust from the acceptable chips. In each unit the top screen has a 2" opening wire, the middle screen a $\frac{1}{2}$ " opening and, the bottom or sawdust screen a $\frac{1}{4}$ " opening. This latter is really a separate unit by itself.

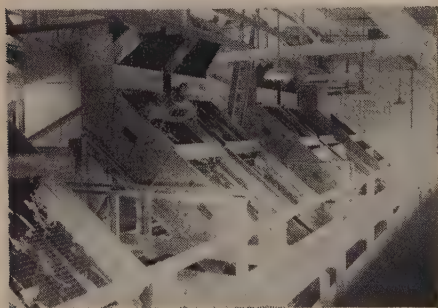


Fig. 31
Vibrator Chip Screens

In this type of screen, the wire surface is held very tightly in the frame

and vibrated 25 times per second by means of an armature operating on a current supply of specially regulated frequency. This mechanism requires considerable attention to keep it in good shape, but if operating correctly at the proper frequency and amplitude will screen the chips rapidly and to size without upending thin chips to pass through the mesh endways. A load of 12,000 feet per hour is handled by each unit of four screens.

Sawdust is sent directly to the boilers. Oversize chips, slivers or "cards" rejected by the 2-inch screen are delivered by a belt conveyor to a 36-inch Lombard chip crusher. This is a high speed machine consisting of a series of discs mounted on a heavy shaft, each disc having flat hammers mounted on its periphery. These hammers strike the chips and break them up. This machine is more efficient for breaking up cards than for producing chips from slivers. The number of hammers on each disc has been reduced recently to prevent breaking the chips up too fine.

The crusher discharges to a separate vibrator screen unit. This time the oversize material, consisting mostly of twisted grain slivers and knots, is sent directly to the hog fuel belt along with sawdust from the $\frac{1}{4}$ -inch screens.

Chips of proper size from the screening units are delivered either to storage bins at the kraft or sulphite mills or to bins at the chipper plant according to demand.

Thus is completed the conversion of logs to chips. At every step in the process, unusual care is taken to guard against dirty or poor quality wood getting into the system. A determined effort is made to produce clean wood and chips of uniform size, and if any unusual conditions of wood quality are observed, the departments concerned are notified so that necessary adjustments in their processing may be made to insure uniform quality in the pulp.

CHAPTER V

WATER TREATMENT AND FILTER PLANT OPERATION

By G. H. GALLAWAY

The pulp and paper industry occupies a unique position among large chemical manufacturing industries, both in respect to the large amounts of water used and the high degree of purity required in its water supplies.

Cellulose fibers on the machine wire form an excellent filtering medium and unless suspended impurities are removed before reaching the machine, they will be partially filtered out on the wire and appear in the finished sheet of paper. Cellulose is able to absorb and hold coloring matters present in mill waters, also undesirable variations in sizing and dyeing in the beaters will result from changes in pH, color and dissolved salts in the water supply.

On account of the relatively high tannin content in hemlock wood and pulp, a low iron content in mill water is essential to avoid forming iron tannate inks which darken the pulp. Iron concentrations of as little as 0.02 parts per million are considered objectionable.

From the foregoing it can be seen how vital it is to have the proper quantity and quality of water for paper manufacture. In fact, this consideration is very often the deciding factor in choosing mill sites. Water problems here on the Pacific Coast are not as severe as in most Eastern mills. The surface waters are relatively clean and soft. However, nowhere are found water supplies in sufficient quantities and sufficiently free from color, turbidity, organic matter, bacteria, algae, fungi and dissolved salts to meet the demands of a bleached sulphite mill without some kind of treatment.

Chemical treatment consists primarily of alum addition for the purpose of forming a floc of aluminum hydroxide. The alum floc forms small, soft particles which float along in the water. Dissolved organic color is attracted to the particle and the suspended materials adhere to it until the particle becomes so heavy that it gradually settles out. Copper sulphate is also added during the spring and summer months in order to kill algae growth. Algae is an organic material which is carried down in the water plugging the filter beds. When the algae has been killed by the copper sulphate it shrivels up and is then in a condition where it may be settled out by the

alum floc. Bacterial growth which is responsible for slime conditions in the mill is combated by sterilization of the water with chloramine.

Mixing of the chemicals with the water is accomplished usually in either round or square chambers by means of revolving agitators.

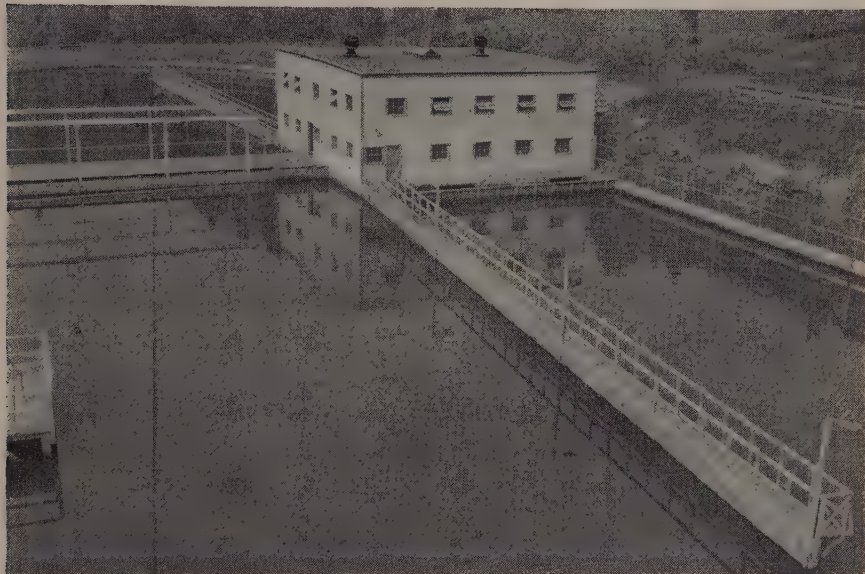


Fig. 32 Settling Basins

After mixing, the water passes into the settling basins where it remains for a period ranging from two to six hours during which period the floc, carrying its accumulated load of color and dirt, may have ample time to settle out.

Water is obtained from two sources—Lackamas Lake and the Columbia River. Naturally the use of lake water is preferred because it arrives at the forebay entirely by gravity, whereas river water is pumped from the Columbia River and the 50,000 G.P.M. pumping installation requires considerable power.

The difference in elevation between the forebay and pumping station plus pipe friction amounts to a 200 foot head.

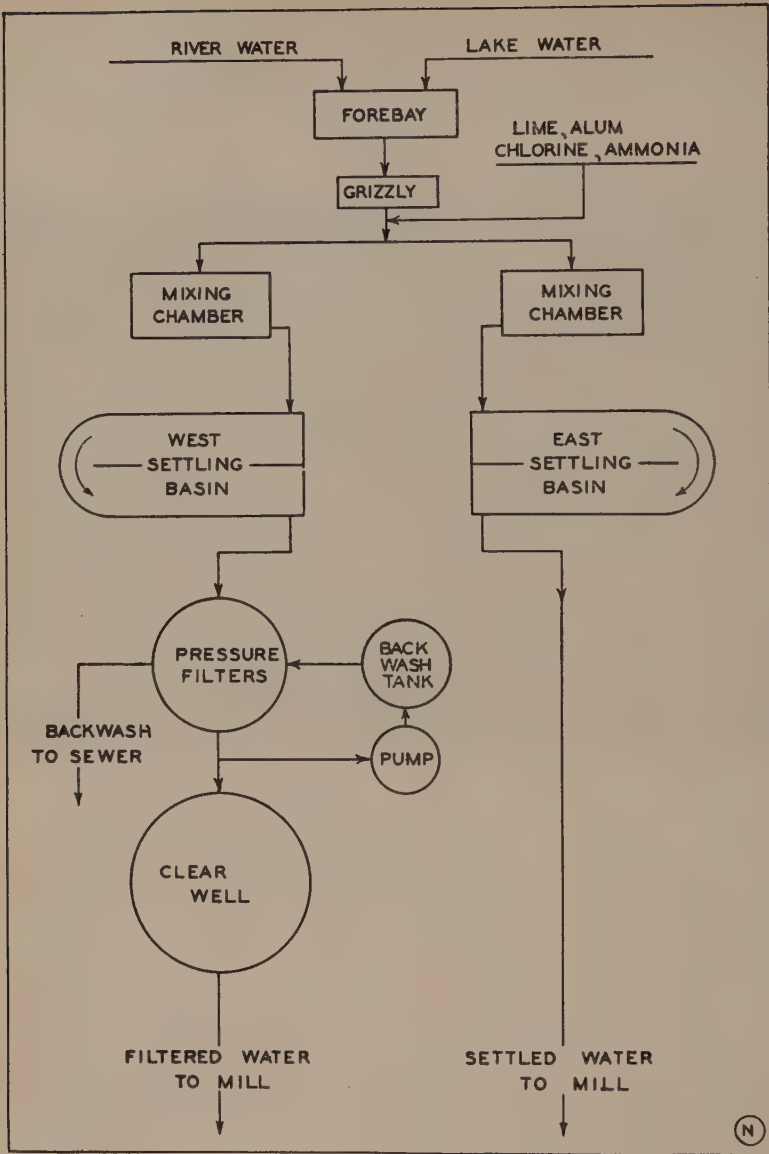


Fig. 33 Flow Sheet of Camas Water Treating System

Camas Mill uses three different kinds of water:

Type	Approximate Daily Usage Gallons	Treatment	Principal Uses
Raw Water	16,000,000	None	Boiler Treating Plant Sulphite gas coolers Kraft Mill condensers Grinder Power Turbine condenser
Settled Water	30,000,000	Treated and Settled	For general use on un-bleached sulphite and kraft pulp papers.
Filtered Water	12,000,000	Treated, Settled and Filtered	General use on bleached sulphite pulp and papers.
Total Usage	58,000,000 gallons		

Fig. 33 shows a flow sheet giving a general idea of the Filter Plant operation.

Both lake and river water enter the system at the forebay and pass through a grizzly which removes brush and other accumulated debris. A 54-inch line carries the water from the forebay into a header chamber located near a concrete wall which separates the basins. There it is distributed into separate mixing chambers where the desired chemicals are added by means of mechanical feeders and well distributed by motor driven agitators. The water, now treated, is discharged into the basins. At Camas the East Basin, used entirely for settled water, has a capacity of 4 million gallons and provides a retention period of two and one-half hours. The West Basin, for water to be filtered, holds $3\frac{1}{2}$ million gallons with a retention period of six hours.

After discharge into the basins the water travels slowly out around a baffle, which extends out through the center of the basin, and is finally collected after passing over a skimming weir. Settled water from the East Basin flows directly to the mill through a 36-inch main. Water from the West Basin, however, flows to the filters. Camas has 20 California pressure filters each 25 feet in length and 8 feet in diameter. The filter beds are built up in four layers as follows: Five inches of coarse gravel, five inches of medium gravel, 10 inches of fine gravel, and 30 inches of filter sand. Water enters the top of the filter through a perforated header and percolates

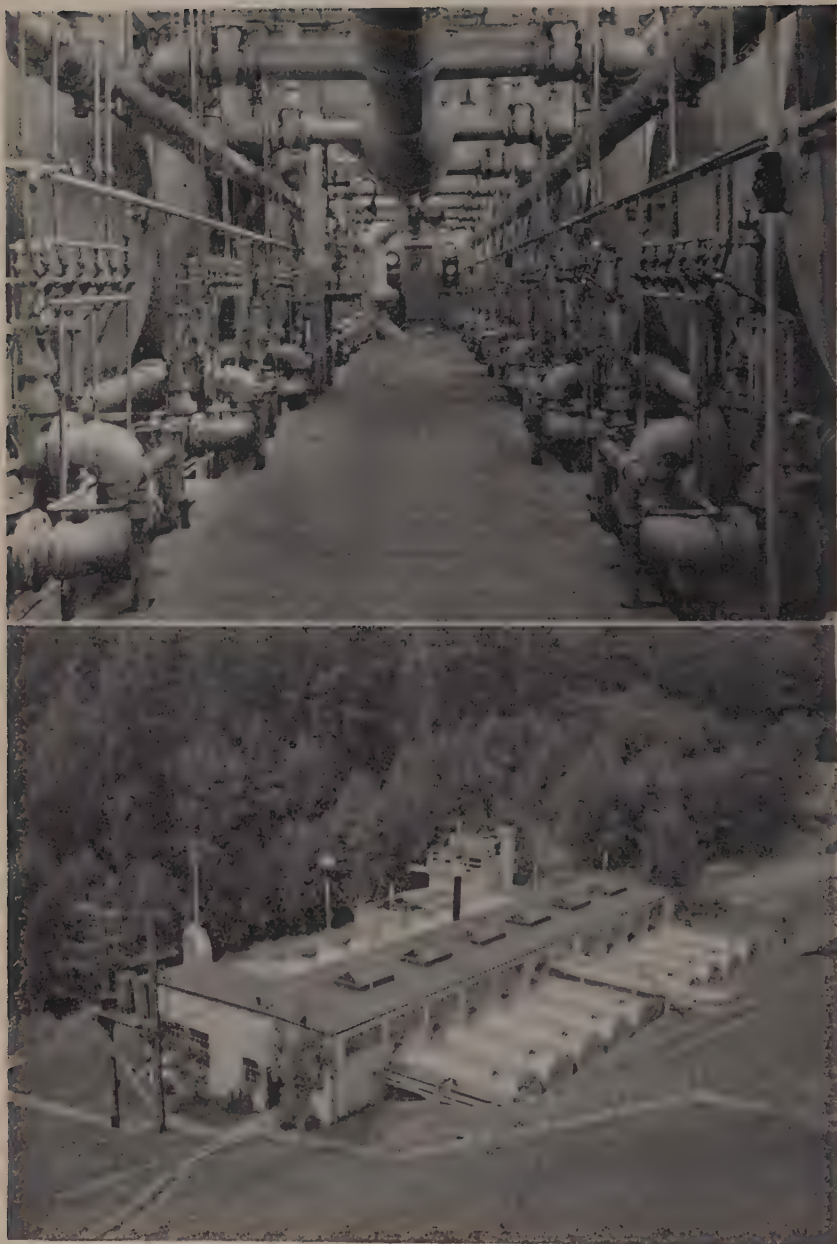
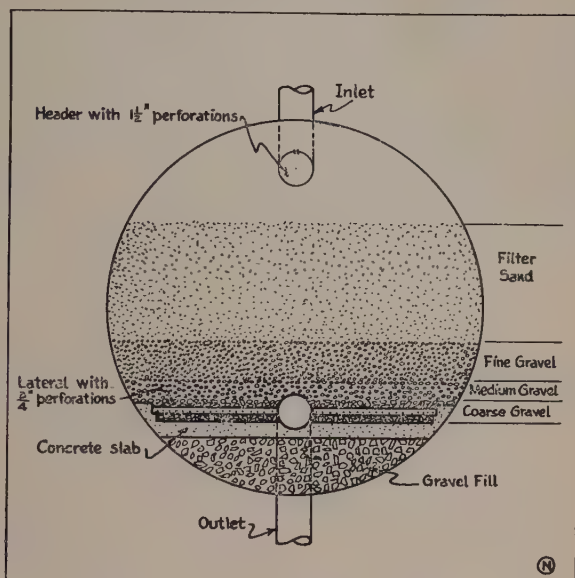


Fig. 34 Pressure Filters

down through the sand and gravel layers, being collected in the outlet pipe at the bottom.

Fig. 35—End Section
of a Filter Bed
Scale 1=2'



After being in service for a certain period enough dirt and floc collect on top of the filter bed to materially retard the rate of flow and it is necessary to backwash, for the purpose of cleaning the filter beds. To do this, the inlet and outlet valves are closed, backwash valves are opened, and filtered water stored in a tank above the filter house flows in at the bottom up through the bed, washing to the sewer those impurities which have gathered. Backwashing is an important and very delicate operation, since too violent a flow may open channels and disrupt the bed and for this reason the constant head from a tank is preferred to the surging action produced by backwashing directly from pumps. Camas filters are divided into two sections of equal size and each is backwashed separately every 12 hours. Filtered water is used entirely in the process and is run back through the filter at the rate of 400 gallons per minute for two minutes; then at the rate of 800 gallons per minute for three minutes; then at 1000 gallons per minute for five minutes. Experience has shown this procedure to give a good thorough washing with no injurious effect upon the beds. The dirty wash water is of course diverted to the sewer.

An important point in the general subject of filtration is that a sand filter of the type described above is of limited value as it stands. What contributes most to its effectiveness is a very thin film of alum floc on the

filter bed which is actually the filtering medium. If untreated water, i.e., water carrying no floc, were sent to the filters, practically all of the coloring matter and fine turbidity would be carried through the filter bed.

Color and turbidity tests are frequently made to check quality of the raw water and filter effluent. Standards made up by the laboratory containing certain definite amounts of color and turbidity are compared visually with the sample at hand. Another important test is the theoretical alum determination which enables the operators to determine the amount of alum giving the best floc for existing water conditions. It is taken once each shift as a control means. Temperature and pH tests are made each shift on raw, settled and filtered water.

Filtered water is maintained quite uniformly at a 0 color and 0 turbidity. Settled water shows on the average a 10 color and 5 turbidity although it is possible to get lower values than this if especially clean settled water is desired under certain circumstances. Raw water quality varies widely depending on the source and the season of the year.

After passing through the filters the water flows by gravity to the "clear-well," a filtered water storage tank holding one and one-half million gallons. Until 1937 the mill pull came directly upon the filters with the result that the flow through them varied greatly and at times may have been heavy enough to do some damage to the beds. Installation of a filtered water storage materially leveled out the flow through the filters.

This clear well, which has just recently been built, was constructed using the Hewitt system of concrete tank design. It is 106 feet inside diameter and 23 feet high. The walls were constructed in vertical sections, and after walls and dome had been completely poured, rods with turnbuckles

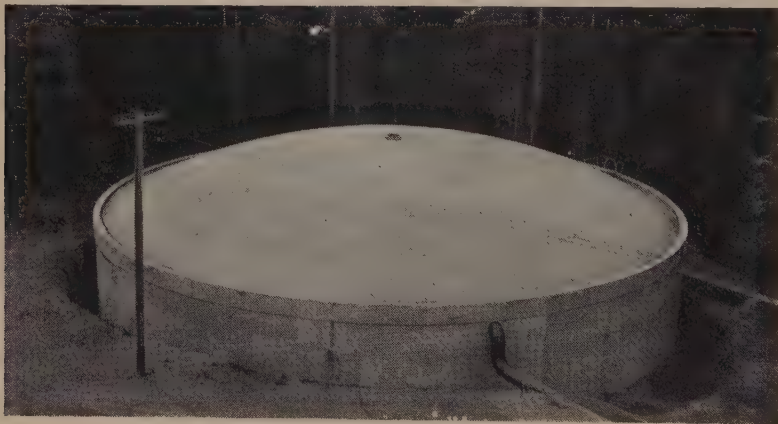


Fig. 36 Clear Well

were placed around the tank and carefully tightened to certain predetermined steel stress limits, then covered with concrete. In this way, the concrete was placed under compression and leakage troubles usually encountered from expansion and contraction stresses in large tanks of this type have been largely eliminated.

To insure even operation, direct acting Venturi Flow Controllers were installed on each of the twenty filters. The controllers can be set so as to allow flow through them up to a certain maximum rate. At present they are set at 0.8 million gallons per day maximum flow per filter. Flow between filters and clear well is controlled from the filter house by means of a hydraulic valve.

Slime Control

The pulp and paper industry is again to a large extent unique among chemical industries in the respect that its products, in course of manufacture, can sustain and promote the growth of certain undesirable microorganisms, referred to generally as slimes.

Slime is a microorganism growth originating from algae, bacteria or fungi sources. The simplest slimes come from water algae and of these at least five species are generally found. They do not attack cellulose. They are tenacious gelatinous growths, usually brown or light yellow, clinging to the inside of pipe lines, sides of chests, in head boxes, riffles and flat screens. They break off, forming the well known slugs or slime holes in paper. These organisms feed on organic matter so that removing organic matter from the water is a sure way to prevent algae slimes.

Other slime types, very prevalent in mill systems, arise from bacterial growth usually in the water. These are extremely active types and attack cellulose. In severe cases, the cellulose breakdown may involve 2% of the furnish weight.

Fungus or mold growths occur mostly in stored pulp and certain of these also attack and destroy cellulose.

Groundwood systems are peculiarly susceptible to slime as groundwood contains more wood sugars and other soluble organics than sulphite or kraft, also the temperatures occurring in groundwood systems are more favorable to slime development.

Slime clogs machine showers, "blinds" or fills the wire, and affects the quality of paper. The means used to combat it are first a copper sulphate dosage to kill algae, then a carefully regulated chlorination to attack bacterial forms. Chloramine, a compound of chlorine and ammonia, is used in preference to straight chlorine as its active chlorine capacity is less rapidly exhausted.

At certain times of the year the mill may be bothered with "plankton" (small crustacea or "bugs") in the water than can pass clear through the system and show up as white specks on colored papers. These white specks are nothing more than the silica skeletons of the bugs and due to the cushioning action of the sheet in the calender stack, these skeletons are so marvelously well preserved that they can be identified as to species under the microscope. Copper sulphate is also used to kill these crustacea.

About 130,000 gallons of water are required for each ton of paper made at Camas, or a total each day of about 58 million gallons, more than the entire requirements of the city of Portland, Oregon. In addition to removing impurities from pulps by washing, and for cooling and steam generation, water constitutes the belt along which moves the steady stream of wood blocks and fibers in their course from wood room to paper machine wire.

Water is not purchased in the same sense as other raw materials. Rather, it is borrowed from the streams and rivers of the state and returned to them when it has served its purpose.

CHAPTER VI

MANUFACTURE OF MECHANICAL PULP

By FRED SIEVERS

The realization of wood as a source of paper making material came only after many years of experimentation. Nearly 2,000 years ago the Chinese made paper from the leaves and inner bark of the mulberry tree.

A number of experiments are noted in making pulp by disintegrating the fibers by rubbing wood on stones as early as 1769, but it was not until 1855 that we have record of a United States patent for making pulp on a revolving stone similar to the common grindstone used in tool sharpening.

Although the Americans first patented the idea, through lack of proper encouragement or other reasons, it was left to the Europeans to bring this process into commercial production in about 1879.

The Grinder

A grinding machine is primarily made up of a grinding stone carried

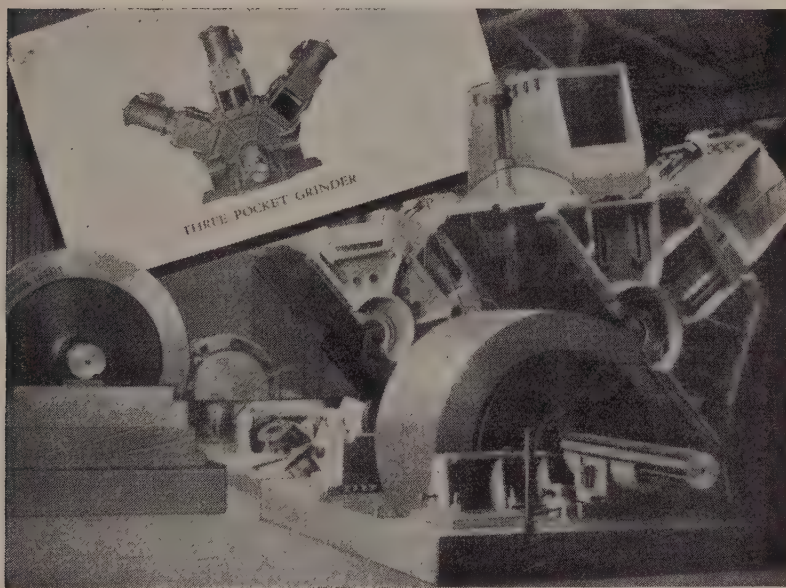


Fig. 37 Pocket Grinder

on a shaft supported by bearings set close to the stone. The stone is covered by a cast iron housing or case composed of the side plates, held together with cross bars on which are carried the pockets, consisting of iron box-like receptacles in which the wood is placed to be ground. On these pockets are mounted the hydraulic cylinders made up of a cylinder, piston head and the piston rod, which extends into the pocket and to which an iron "press board" is attached.

The piston is operated by a four-way valve. The operator throws the valve in one position, causing the water to flow into the cylinder on the bottom side of the head and at the same time automatically releasing the water from the top side of head, thus the head rises, causing the press board in the pocket to rise to the top of the pocket. With the press board at the top, the operator places the wood in the pocket beneath the press board. By reversing the four-way valve, the action of the piston is reversed and the wood is pressed against the stone, much in the same manner as an old-fashioned brake block presses against a wagon wheel.

The stone must be submerged in a pit called the stone pit, and water must be showered on the stone or into the pit, otherwise the stone would heat up and burn.

Camas has 16 grinders, some of which are operated by motors and others by water wheels. The stones are 54 inches in diameter.

STONES

Sandstones

Sandstones are stones quarried from large beds of this rock. This sandstone must meet some general specifications, but actual tests are necessary to determine whether or not a stone is suitable.

The binder holding the particles of grit together must be soft enough to wear faster than the sand grit itself, but must be hard enough to hold the grit in the surface while exposed to the grinding against the wood. The binder is greatly varied. It is usually composed of carbonate of lime or silica compound, being a sort of natural cement, which is very uneven and stones from the same quarry are often very different.

The stone must be strong enough to withstand expansion due to temperature ranges encountered in grinding. It must be tough enough to run at speeds of 250 to 260 R.P.M., which in an ordinary 54" stone gives a peripheral speed of from 3700 to 3900 feet per minute.

Norton Stone

This stone, first developed in 1928 by the Norton Stone Company, is

composed of carbide of silicon. The stone is made up of blocks of this material mounted on an iron pod and iron keys, bolted to a common center, hold the blocks in place.

The grit, of which the stone blocks are composed, is bound together with a vitrified bond which is impervious to water. These segments or blocks are separated with a filler of some sort to allow for expansion and contraction.

Fig. 38
Norton Stone



In the first construction, babbitt was used for segment separation, but due to the fact that the babbitt did not wear down evenly with the face of the segments, it was necessary at times to chip the babbitt, which protruded between the segments, down to the stone face. This necessarily was done by hand and involved a great deal of labor. Also, the babbitt, being hard and protruding from the stone face, caused the jig roll to jump when sharpening the stone, breaking the edges from the segments causing the stone to make a great deal of waste.

In the present construction of Norton stones, this feature has been eliminated. They now use an insert of rubber and cork between the segments of stone. This material wears down evenly with the face, and, being soft, cuts down with the jig roll when sharpening. The Norton stones come to the mill a well finished job. There are adjusting screws in the eye with which it is possible to center the shaft in exact alignment with the face of the stone. In setting up the washers, care must be taken that in no place does the washer touch the segments that make up the cutting part of the stone. An iron hub on each end of the pod provides for a friction bond between the stone and washer that holds it in place on the shaft.

Aloxite Stone

In the Aloxite stone, made by the Carborundum Company, the grits are composed of aluminum oxide. The grit is bound together with vitrified clay impervious to water as in the Norton stone. But here the similarity ends. The segments of the Aloxite stone are bound together with a soft filler between the segments and the stone is then baked in an oven, making it, in a sense, a solid mass. Iron rings hold the central blocks together, giving added strength to withstand centrifugal force. The stone is mounted almost the same as a natural sandstone.

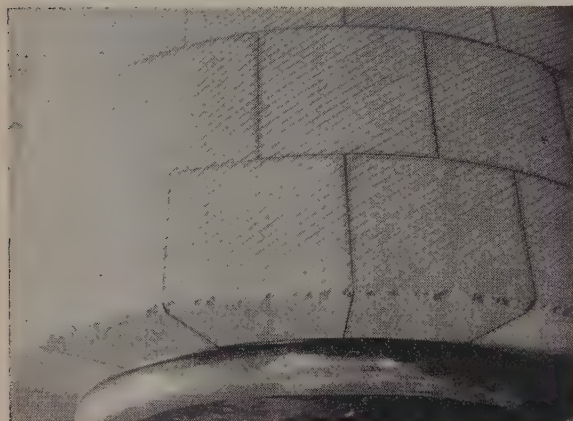


Fig. 39
Aloxite Stone

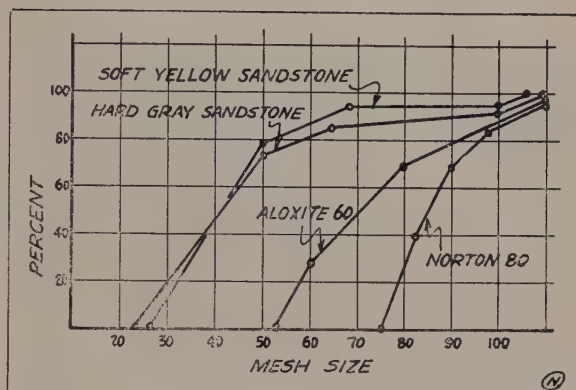
Comparison of Artificial Stones

The artificial sandstones, the Aloxite and Norton, are comparable in performance, but the stock and other features of these stones differ widely. The grit that goes to make up the Norton stone is sharp and angular, the grit of Aloxite is rounded and not unlike the grit found in sandstones. However, the Norton stone is three times as strong as the sandstone and the Aloxite is stronger than the Norton.

The particles making up these stones are screened through fine mesh screens. Each stone possesses definite size grit particles in its construction. The numbers given for them, 50, 60 and 80, indicate the mesh sizes of the grits. The early work done at Camas was on an Aloxite 60 and a Norton 80, and therefore is not a true comparison of the relation of pulp made with these stones. However, due to the fact that the 60 grit was slightly too large and the 80 grit too fine, it was decided to order an Aloxite and Norton both in the 70 grit size for West Linn.

From Fig. 40 a direct comparison of the sandstones which are now used and the artificial stone which Camas is adopting can be seen. Whereas consideration has been given to the use of stones of 70 grit, the present

Fig. 40
Comparative
Grit Sizes



stones are comparable to a 40 grit. This accounts for a great deal of coarse pulp and waste made by sandstones. It has been impossible to use sandstones with exceedingly fine grit due to the fact that they would not carry water enough to keep from burning when in operation.

Jigging Stones

Jigging is the common name for sharpening the stone. The name, while implying little to present day practices, is a holdover from days when a man took a long bar with an iron burr (jig roll) held in a fork at one end, and by resting the bar over a crosspiece in front of the stone, pressed the burr, leverwise, against the set revolving stone. As the stone revolved and the burr hit hard and soft places, the operator did a sort of a shimmy dance to the shaking of the bar. Therefore, the word "jigging."

Modern jigging is done with a lathe-like contrivance. An iron head is carried on a flat crossbar or rods, in such a manner that the head can be carried across the face of the stone. Two forks projecting from the head carry the jig roll. The head is adjustable, so that the part carrying the jig roll can be moved ahead or back, thus allowing the operator to press the roll against the face of the stone.

The jig roll is made of steel, being about 3" in diameter and about 3" across the face. Through the center is a hole about 1" in diameter, through which an iron pin is thrust. The jig revolves on this pin when brought into contact with the revolving stone. On the faces of these jig rolls are cut teeth similar to cog wheels, but very fine, running from 6 to 14 cuts

to the inch. There are many different designs. Some are spirals, diamond-shaped, straight cuts, chisel tooth, etc. The cut of the burr and the number of cuts have a distinct bearing on the quantity and quality of pulp produced.

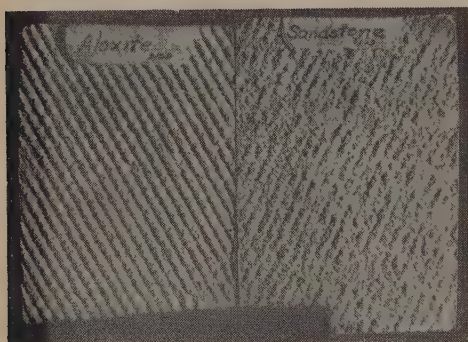


Fig. 41
Comparison of Jig Impression
Between Sandstone
and Artificial Stone

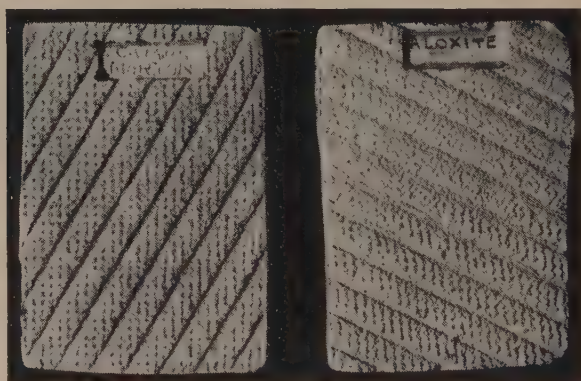


Fig. 42
Method of Double
Dressing Stones

Jigging is of two-fold importance in grinding operations. First, the stone must carry on its face sufficient water to prevent excessive heating when in contact with the wood. The grooves or jig markings allow the stone to carry this water. A very smooth stone will heat up to a temperature at which the wood will burn. Second, it is a means of governing the quality of the pulp, the fine cut burrs giving finer pulp than the coarse burrs.

Plaster of Paris casts are made of the stones so that their patterns will be on record and can be correlated with operating and pulp data. Some of these casts are shown in Figs. 41 and 42

It has been found through many tests that the jigging of stones is not as important as the grit size of the stone itself. There have been many burrs used—spiral, diamond and thread burrs—and all of the results were only slightly different. They are not as widespread as is often supposed. Very little can be said on rules to sharpen stones. The quality of the stones used govern the way in which the stone should be jigged. A few set rules that may be followed when jigging, are that a right hand spiral would

Fig. 43
Jig Head with Burr
in Place



always be used from the right side when facing the stone and the left hand, from the left side. The same applies to the use of a thread burr. This is obvious when we consider that the spiral burr is an elongated thread and the cut of the burr used in this manner will tend to draw the burr in the direction which it travels. If it were used in the opposite direction, the right hand from the left side and the left hand from the right side, the true impression of the burr would be partially obliterated. No doubt the stone would be made rough enough to cut, but no benefit would be derived from the special cut of the burr.

One thing that has been brought out in Camas jigging operations is a broader use of the smooth roll in jigging. The artificial stones when newly jigged, produce waste pulp that is distinctly waste, unlike sandstones, where part of the waste is oversized fiber and causes the operator to debate in his mind whether it is too large to pass a screen or not.

To eliminate this waste from artificial stones, a smooth roll is passed lightly over the face of the stone. It is not set up hard enough to touch all parts of the stone but just enough for the high spots to touch the smooth roll causing it to turn very slowly and, as the high spots hit the smooth roll, they are brushed from the stone face. This use of a smooth roll was

introduced by the manufacturers' representatives of artificial stone companies. The results on the artificial stones indicated that the smooth roll could probably be used to some advantage sandstones. However, after jiggling a sandstone with a light roll of this kind, where only the very high spots hit the roll, the stone actually increased its production. Also there were fewer coarse fibers and less fibrillation. This is really easily explained when one considers that the coarse grit protruding from the face of the sandstone when it contacts the wood, immediately tears off a large sliver which, in passing between the wood and the stone, regrinds, filling the cavities in the stone face that are directly in its vicinity and thus preventing the finer grits in the stone from cutting the wood.

With artificial stones, jiggling is entirely different than with the sandstones. With a sandstone the impression is placed on the face of the stone by crossing over once. Makers of artificial stones recommend that this impression be worked into the face of the artificial stone slowly. It is necessary to pass over the face of the stone three or four times to give the proper impression in the stone face. This working the jig impression into the stone face is entirely feasible due to the strength of material of which the artificial stone is made. Also putting the jig impression on in this manner does not rupture the bond holding the grit particles together and tends to increase the length of time between sharpening. The jiggling cycle of an artificial stone is from one to seven days, but, in the case of a sandstone, it is necessary to jig every six or eight hours. After the jig impression is once put on the artificial stone, it is only necessary to go over the stone face once to retouch the impression to the sharpness desirable for good production. This accounts a great deal for the difference in life of the artificial stone as compared to the sandstone. One of the things tried that was out of the ordinary, was the use of a spiral marking burr. Marking burrs are a part of the Hall & Ward process brought out many years ago. The straight cut marking burr was used in this process and some very good results were obtained with its use. However, the cut of the marking burrs they used were straight across the face of the stone and although it improved the quality of the pulp, was found to increase the amount of waste. It therefore did not meet with hearty approval.

In making these tests it was suggested that a spiral marking burr be used. The use of a spiral marking burr was found to eliminate the disadvantage of the increased waste. It was also found that on sandstones it gave a greater amount of unfibrillated pulp which the mill was trying to produce. However, the sandstones are too soft or not strong enough to hold this impression well, and some work is necessary to find a sandstone that would be stronger and more desirable for the use of this method of stone sharpening.

Grinding Pressures

In ordinary conversation, grinding pressure is often spoken of as the gauge pressure of the water in the hydraulic cylinders on the grinder. This, as a matter of comparison, is erroneous. Cylinders on grinding machines vary in size from 12" to 24". For example, a 12" cylinder with 55 pounds

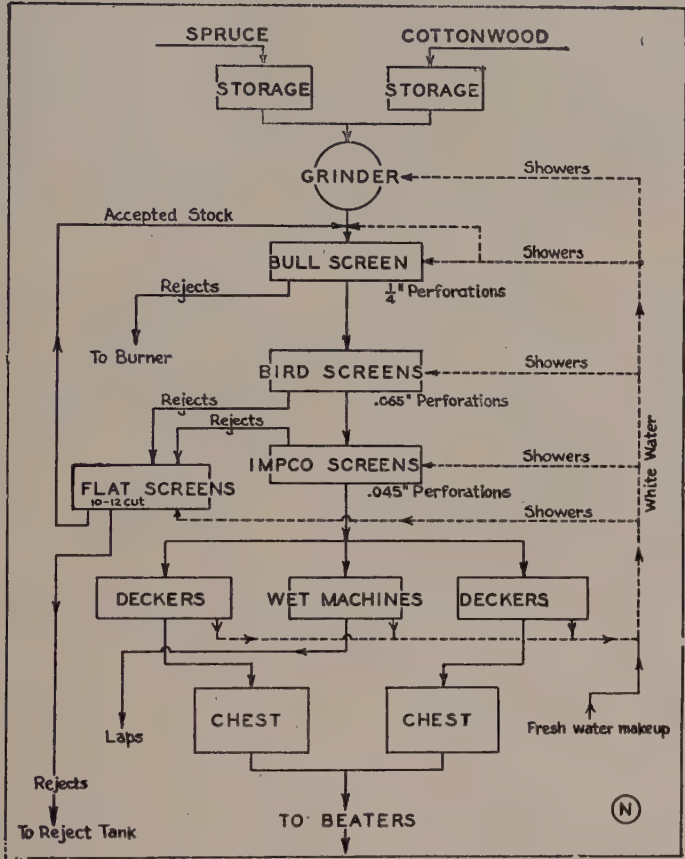


Fig. 44 Flow Sheet of Groundwood Mill

pressure would have a brake force of 6,220 pounds. A 16" cylinder at the same water pressure in pounds per square inch would have a force of 11,058 pounds, nearly twice as much.

The actual grinding pressure is at the point of contact of the wood against the stone. Thus an actual grinding pressure would be worked out on the following formula:

$$\text{Grinding Pressure} = \frac{\text{Cylinder pressure x area of cylinder head}}{\text{Length x the width of the pocket}}$$

Although small and large blocks are put in the pocket, seemingly giving a greater range to the pressure, in most cases, the pocket at the point of stone contact is usually full. However, this produces some variation in actual pressures.

Another variable is the binding of wood in the pockets. This takes an appreciable amount of power and tends to cause variable pressures.

Many grinders are governed by changing the pressure, thus keeping the load even and it has been proven that though the gauge pressures vary, due to tight and empty pockets, a more even grade of pulp is produced with this method.

Grinding Temperatures

Grinding temperatures are often compared between various mills. Many theories are given on the values of hot and cold grinding. Most comparisons of grinding temperatures are made by comparing actual degrees of heat in the stone pit. This is most always erroneous.

If a relative temperature of stock leaving the stone and a relative temperature of the water showered on the stone were compared, the comparison would be instructive because correct.

There is an old theory among many paper makers with a superficial knowledge of grinding that cold grinding gives lighter colored pulp than when hot ground. This is true only within certain limits.

To control the heat on a grinder the shower water is adjusted. The shower water is reduced to heat up a stone, and increased to cool down a stone.

When there is a decrease in the shower water, the consistency of the pulp in the stone pit increases. The stone having less water to lubricate it at point of contact with the wood tends to scorch the wood, causing it to turn brownish and the pulp has the same color.

With increased shower water, the stone has plenty of lubrication and the wood is not scorched. Therefore, it comes out with its natural whiteness.

In a number of tests made with shower water heated, where the consistency of the pulp in the pit was kept low, no noticeable difference in color was noted. Samples of pulp ground at from 150 degrees to 200 degrees, where the consistency was the same, showed no noticeable difference in color. These samples of pulp were checked for color by the International Dye Service of Canada, and bore out the mill's conclusions. But all samples

of pulp ground at high consistencies showed a falling off in color regardless of temperature.

Shower Water and Temperature Control

In the grinding of pulp the shower water, or water that is used to keep the stone cool while grinding, has never been given much thought in the mill. However, when we consider that well over one hundred tons of water are used to grind seven or eight tons of pulp and that two-thirds of this water is heated from a given point to 80 or 90 degrees higher than when it entered the stone pit and that at least one-third of the water passes off from the stone in steam, it looks like a different problem. All of the horsepower delivered to the stone is converted to heat due to the friction of the stone against the wood. This heat is controlled by spraying water on the stone face which acts as a lubricant between the point of wood and the stone contact.

In checking up on a grinder stone using 550 H.P. it was found that 322 H.P. were used to heat up the water supplied to the stone 80 degrees; 200 H.P. passed away from the stone in steam, the remainder probably was thrown off by heat in radiation. Previously the amount of water on the stones changed a great deal and this resulted in variation in stone temperatures. However, controls have now been developed to take care of this operation and they have proved to be very satisfactory at Camas.

In looking at Fig. 45 there is revealed the number of gallons used at different consistencies and stone pit temperatures. The best consistency

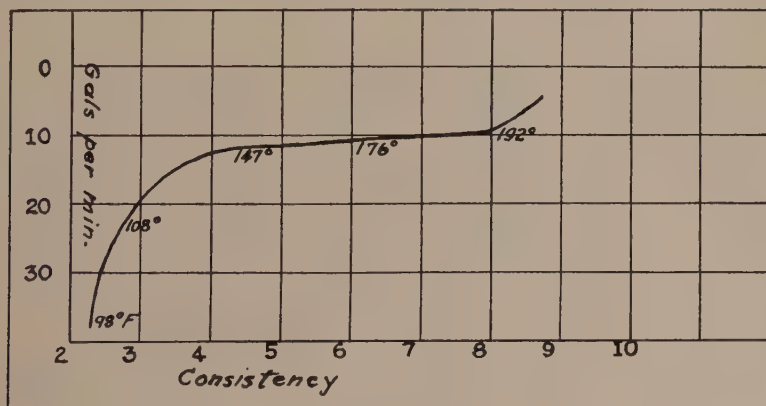


Fig. 45

to grind is probably around 4 to 5 percent; however, with hand operation, this is hard to do, due to the fact that about 15 gallons per minute of water are used to hold the stone in these limits. Also it is harder to control a large

amount of water than a small amount of water which is used when grinding at 8 or 9 percent, as is now practiced in most news mills.

Referring to Fig. 46 we find a comparison between the heat of the stone face proper and the pit temperatures. Ordinarily we think of only the pit temperature, but in the grinding of wood it has been found that the face of the stone is considerably hotter than the pit. This is easily understood when it is considered that part of the water is turned to steam

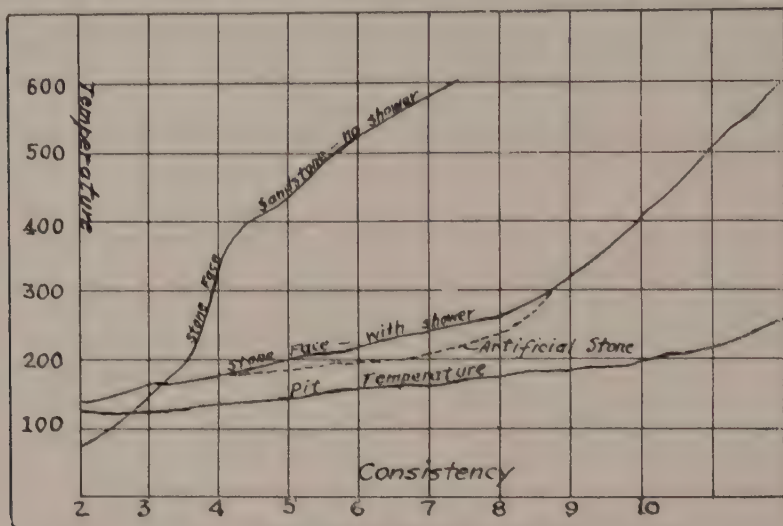


Fig. 46

and yet enough heat is given off to heat the stone pit up to a high degree of temperature. At the lower consistency, 4 to 5 percent, the stone face does not reach the boiling point although the exact time that it is in contact with the wood is probably much higher. But at the higher consistency, 7 or 8 percent, it would seem that even the temperature of the stone face is much higher than the boiling point, and that around 9 percent; over 300 degrees of heat is registered by the stone face in either an artificial stone or a sandstone. At this temperature, burning or caramelizing of the wood sugars begins, causing the pulp produced to darken in color. However, as previously stated, most of the pulp produced in other mills is ground at these high consistencies due to the fact that it is so difficult for the grinderman to keep the consistency uniform and obtain a good production by manual control.

Also from Fig. 46 it will be seen what happens when the shower water is completely shut off from the grinder. The time for burning, after the stone has gathered all the water it can from the pit, is around a period

of from 4 to 6 minutes. This often happens with hand controlled grinders due to the fact that when jiggling, the pulp is thinned down and to get them up to proper consistency where they will run more evenly, the operator shuts off the water and fails to turn it on before the stone burns.

In Fig. 47 is shown the arrangement of the thermometer used on the shower controlling instruments as made by both the Foxboro and Taylor Instrument companies. The thermometer bulb extends across the entire face of the stone and must be submerged in the pulp to give proper control.

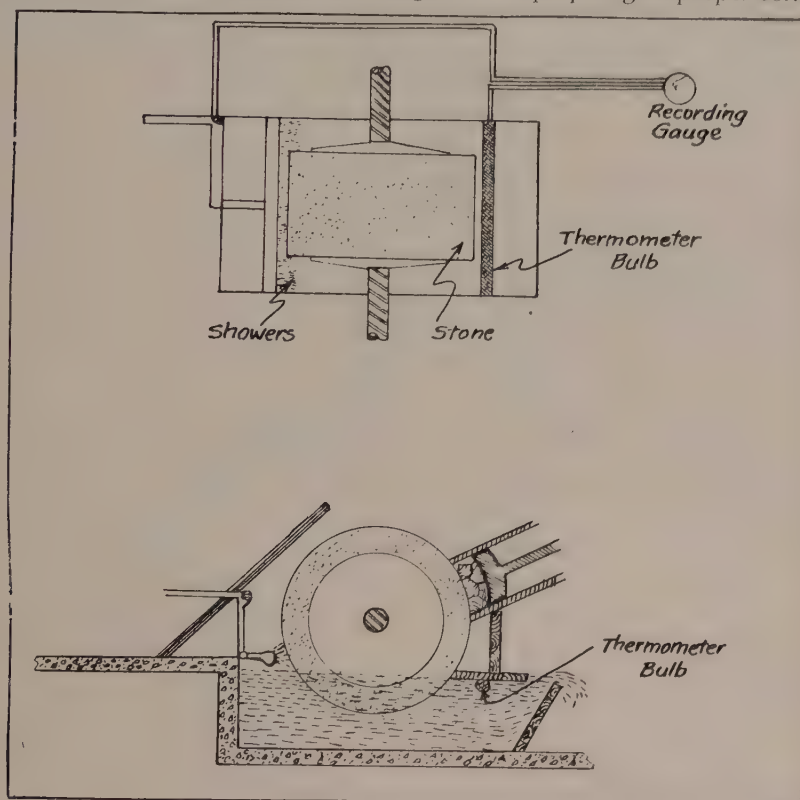


Fig. 47

In using these temperature controls it has been found that best results are obtained by using a shallow stone pit, one that is about nine inches below the bottom of the stone face. These instruments were found to keep the stone pit at a very even temperature maintaining a uniform production and giving a longer period between jiggling times, due to the fact that there was less change in temperature on the face of the stone, and therefore less chance to rupture the binder holding the stone grit in place.

It was found that freeness could be changed readily by lowering and raising the temperature in the stone pit. This also allowed for longer periods between jiggling due to the fact that, as a stone dulled, the temperature could be raised slowly and, without an appreciable increase in power the production could be increased and freeness could be held to the desired range. This is shown readily in Fig. 48. However, this one feature brought out another angle of this control very plainly; this was the fact that any change in the relation between pit temperature and the shower water temperature voluntarily made the stone face hotter or cooler as the case might be, and increased or decreased the consistency—if cooler, increased the consistency and freeness, and, if warmer, decreased them.

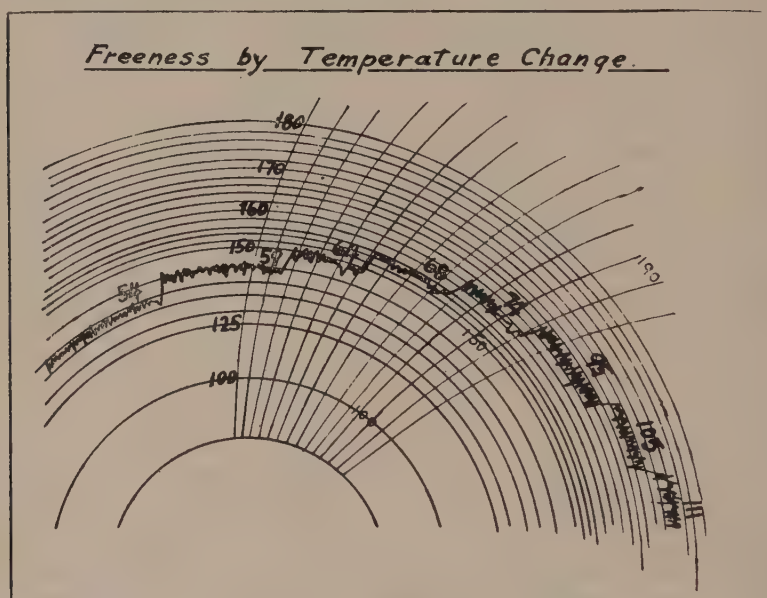


Fig. 48

Grinding Power

The grinding of mechanical pulp requires a great deal of power. Before electricity became widely used, groundwood mills were built where an abundance of water power was available, but with the development of electric motors and the transportation of electric power economically, it was possible to locate paper mills using groundwood at most any point desired by the manufacturer.

The use of electric motors was found to be a great step forward in grinding. More even speeds made for better stone sharpening and better

control in every way of the pulp produced. Pulp mills could be kept cleaner, giving better working conditions to the men employed. With the use of electric power it was not necessary to place grinding rooms in basements to get the full advantage of the flow of some river or waterfall, but they could be built wherever desired.

The amount of power required to produce a ton of pulp is variable. Many factors go to make up the power used. The kind of wood, type of grinder stone, the temperature of grinding, the peripheral speed of the stone, the application of pressure on the wood and the quality required in the paper made from the pulp produced, are all contributing factors.

Much of the power delivered to a pulp stone is converted to heat and thus the percentage of actual pulp production per unit of energy seems very inefficient.

The amount of heat unaccounted for in the form of radiation, steam, etc., has been estimated at 10%, although the actual loss may be higher than this. Conversion of power into heat was determined from the relation: 1 H.P. day = 61,200 B.T.U. The specific heat of wood is taken as 0.33 and the wood moisture calculated also in the heat balance. Data evolved from these calculations are summarized below:

B.T.U. ABSORPTION (10³)

Wood	Stone	Con- sist.	Lbs. B. D. Day	Pit Differ- ential ° F	Wood Differ- ential ° F	Wood	Water	Radia- tion	Heat Equiv. H.P.	Power Input	% Power into Useful Work
Hemlock Hemlock	Sandstone Nortons	7.8 (No con- sistence)	42,000	114 reported	100	1385	50,020	5140	922	1258	26.7
Spruce Spruce	Sandstone Nortons	7.6 7.6	46,000 37,200	113 119	99 105	1505 1290	56,260 48,300	5765 4959	1040 898	1155 1090	9.9 17.6
White Fir White Fir	Sandstone Nortons	7.9 8.1	41,300 42,000	114 110	100 96	1364 1330	48,890 46,330	5025 4766	902 857	1070 1050	15.7 18.4

These results indicate the very large amount of power that is lost to heat in the grinding operation. The above tests on sandstones were taken just after jiggling so the power efficiency is the maximum that could be expected from natural stone. On the stones (using Spruce and White Fir) where comparative data are available, the average efficiency with Nortons is 18.0% and with sandstones 12.8%. This is a further indication of the greater efficiency of the artificial stones in utilizing power.

Campbell has calculated the surface energy of Eastern wood (C. P. & P. A. Technical Papers, 1934):

Surface energy of groundwood (at 650 ergs./sq. cm.) = 0.793 watt-seconds/gram.

Converting an average power of 52.5 H.P./days per ton into above units we find: 3,730 watt-seconds per gram. The percent efficiency on this basis is 0.21. This is considerably lower than the power data above indicated.

EFFECT OF WOOD SPECIE ON FRICTION COEFFICIENT

Average values for the coefficient under comparable loads are:

(a) Sandstone:

Spruce.....	0.193
White Fir.....	0.178
Hemlock.....	0.159

(b) Norton:

Spruce.....	0.188
White Fir.....	0.170
Hemlock.....	0.163

These data lie in the same order found in grinding these woods. Hemlock grinds the easiest and spruce the hardest, with white fir intermediate between the two.

The following formulas for calculating grinding power will give complete data on the principal factors involved in grinding power:

Meyers' Formula (TAPPI Tech. Papers V.P. 25, 1922):

$$C = \frac{33,000 \times \text{H.P.} \times 12}{P \times A \times N \times R \times D \times \pi}$$

Where C = coefficient of friction

H.P. = horsepower per grinder

P = cylinder pressure

A = area of cylinders

N = number of pockets per stone

R = revolutions per minute

D = stone diameter

π = 3.1416

Using Camas data:

$$C = \frac{33,000 \times 650 \times 12}{55 \times 201 \times 3 \times 247 \times 54 \times 3.1416} = 0.185$$

Sievers' Formula (Pacific Pulp & Paper Magazine, April, 1930):

$$f = \frac{33,000 \times \text{H.P.}}{P \times V}$$

Where f = coefficient of friction

H.P. = horsepower per grinder

P = total pressure on cylinders

V = peripheral speed f.p.m.

Using Camas data:

$$f = \frac{33,000 \times 650}{3 \times 201 \times 55 \times 3500} = 0.185$$

This formula is the same as Meyers' with terms condensed.

Note: Basis of 650 H. P. per grinder is 12.3 cords day at 54 H.P. per cord obtained on Camas 80 Norton.

We have calculated "Sievers' Formula" values of friction coefficient for the Port Angeles tests on sandstones and Nortons. Comparative values for some Eastern newsprint mills are also given.

MILL	Cylinder		Pocket		H.P. per Ton	Tons per Day	H.P. Input	Approx. R.P.M.	Periph. Speed	Free C.S.F.	Friction
	Diam.	Lb. per Sq. In.	Area	Lb. per Sq. In.							
W.P.P. Corp.-Sand.	14"	67	2295	27.0	50.8	22.9	1165	240	3282	169	0.189
W.P.P. Corp.-Nort.	14"	70	2295	28.2	53.4	22.7	1210	240	3378	110	0.140
Flinch-Pruyn	22"	60	3200	29.0	57.0	20.0	1140	220	3570	110	0.113
Great Northern	22"	100	3200	50.0	58.0	27.0	1565	220	3570	85	0.091
Algonquin	14"	90	1200	35.0	59.0	10.5	620	240	3400		0.143
Blandin	16"	47	1200	26.0	59.0	14.0	825	240	3770	140	0.232
St. Croix	22"	62	3200	31.0	60.0	20.0	1200	220	3570	100	0.112
W.P.P. Sand. 6.'36.	14"	74	2295	29.9	55.2	17.9	986	240	3090		0.153
W.P.P. Nort. 6.'36.	14"	74	2295	29.9	54.0	19.5	1050	240	3140		0.162

Considerable variation in coefficients of friction are indicated. We have plotted the relationship between pressure per square inch of pocket area and friction coefficient as shown in Fig. 49

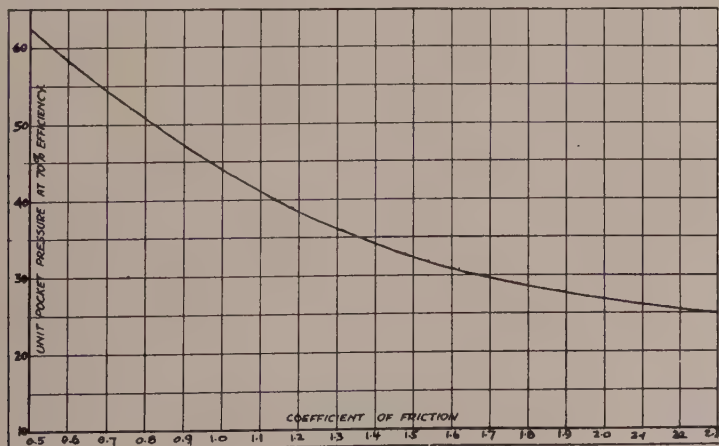


Fig. 49

The curve shows that pocket pressures much below 25 pounds per square inch will result in high coefficients approaching the coefficient of sliding friction. The maximum heat and least useful grinding occurs at this point. As pressures increase, the coefficient of friction decreases until at a value of 50 pounds or over, the greatest efficiency of power transformation into useful work is obtained.

CHAPTER VII

MANUFACTURE OF KRAFT PULP

By J. H. HULL

History of Process

The kraft process was invented in 1889 by the German chemist, Dahl. He obtained backing and started a mill in that year, but was unable to complete it because of financial difficulties. Dahl then went to Sweden and there again obtained financial backing for his process. The mill constructed in Sweden successfully produced kraft pulp suitable for paper making in 1890-91.

In 1908 an old soda pulp mill in East Angus, Quebec, was reconstructed as a kraft mill, the first in North America. The second was constructed about the same time in Roanoke Rapids, No. Carolina. The Central Paper Company also constructed a kraft mill at Muskegon, Michigan, in 1909. The kraft pulp industry developed rapidly from that date, especially during the period from 1914 to 1928, and during the recent several years in the South, when a number of mills have been built in the states of Alabama, Arkansas, Louisiana and Florida. The Southern pine, commonly grown throughout these states, is relatively high in pitch content, making it less suitable for sulphite than for kraft pulping. This fact accounts for the rapid development of the kraft industry in the Southern states.

The kraft mill at Camas was constructed in 1927, the original intention being to use Douglas fir. It was found that the strength of the pulp from this wood was low and the pulp not as well suited to the grades desired as pulp made from hemlock and white fir, the woods now used.

This method of digesting wood is correctly named the sulphate process, though the term in general use is kraft. This latter is a German word meaning "strength," and was originally used by the manufacturers to describe the strong paper made from kraft pulp. The word has now come into such general usage that it is applied both to the process and to designate the pulp and paper produced.

The kraft industry, in supplying the bulk of wrapping and bag paper and shipping cases, is a sensitive index to the movement of consumer goods. Therefore with improved methods of retail selling, more efficient distribution and display, and newer and better grades of bags and wrapping, the kraft industry has seen a phenomenal growth, considering that it is really a young industry in point of years. Camas plant alone today produces five

times the entire output of United States and Canada some thirty years ago.

General Description of Process

The main features of the kraft process are (1) the preparation of the cooking liquor used in the digesters, (2) the cooking operation, and (3) the recovery of the chemicals in the pulp and spent liquor blown from the digester. The cooking liquor dissolves part of the wood, leaving the fibers or pulp. The dissolved organic matter and the residual chemicals are washed from the pulp with the spent cooking liquor, which, with the wash water, is then concentrated in evaporation. The mixture of residual chemicals and organic matter is finally dehydrated in a furnace. The spray type Tomlinson furnace, such as we now have at Camas, is rapidly replacing the older type of rotary furnaces. Most of the chemicals are recovered by burning off the organic matter in this smelting furnace. The organic matter has sufficient heat value to burn as fuel, so that no additional fuel is needed in the smelter if the process is properly balanced.

The fresh chemicals, generally salt cake and sometimes soda ash, needed to make up the constant loss throughout the mill are added at the smelter. The chemicals discharged from the smelter are dissolved in water, which solution is treated with quicklime to convert the recovered chemicals into the active form needed in the cooking liquor. A heavy sludge is formed in the solution as a by-product of the action of the quicklime, and this

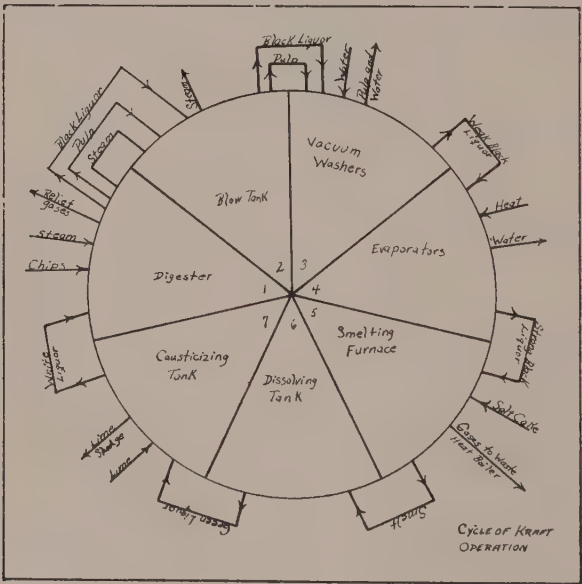


Fig. 50
Kraft Cycle

sludge must be settled out. The clarified solution is the cooking liquor and is then ready to be used in the digester.

Fig. 50 shows the kraft process in the form of a circle and illustrates the cycle through which the chemicals go.

Characteristics of Sulphate or Kraft Pulp

The sulphate or kraft pulping process achieves an effect on the wood chips similar to the sulphite or acid process; that is, the liquor or cementing material which holds the cellulose fibers together firmly in the wood is dissolved, allowing separation of the fibers.

Kraft pulp is brown, however, due to the characteristic effect of the strong alkali cooking liquor on vegetable matter. The fibers are stronger than those from the sulphite or acid cook; first, because the alkaline cooking liquor does not have so drastic an effect on cellulose as sulphite acid, and second, because the sulphate cooking liquor is "buffered" or made less drastic by the presence of the sodium sulphide constituent of the cooking liquor. The soda pulp process is similar to the kraft process in using an alkaline cooking liquor, but in the soda process a liquor of caustic soda alone is used. Soda pulp is likewise brown but not so strong as kraft pulp due to the more drastic soda liquor, unprotected by the sodium sulphide. Soda pulp is relatively easy to bleach to a high white color, while kraft pulp is more difficult to bleach. The sulphide part of the cooking liquor forms certain sulfur dyestuffs and phlobotannins with the lignin part of the wood and these tend to dye the fibers and are difficult to break down by the bleach liquor.

Comparison With Sulphite Process

The sulphite process by comparison uses an acid cooking liquor. This has but little dissolving action on wood resins or pitch. The resins are left in the pulp and tend to plug the paper machine wire when present in appreciable quantities. Consequently, only those woods low in resin content are cooked by the sulphite process. The kraft process uses an alkaline cooking liquor in which the active cooking agents are sodium hydroxide (caustic soda) and sodium sulphide. This alkaline liquor readily decomposes wood resins, which then pass into solution. This property of an alkaline liquor makes it possible to cook practically all woods by the kraft process, though some produce pulp of much higher quality than others. It is for this reason that the Camas Kraft Mill uses hemlock and white fir, both low in resins and therefore suitable for the sulphite process, rather than Douglas fir which is high in resin content and unsuitable for sulphite production. The Mullen or bursting strength of kraft pulp from Douglas fir is low; however, tear strength is generally higher than hemlock.

The acid liquor of the sulphite process makes it necessary to construct the digester linings of vitrified tile or brick, and the fittings of an acid-resistant metal such as bronze, lead, or the recently developed chrome-nickel steels. In the kraft process, however, all of the equipment, including the digesters, pipe lines, pumps and tanks can be made of steel or iron, since these metals are not rapidly attacked by the caustic solutions used. It has been our experience that Monel metal best resists attack by the caustic solutions, and this metal is now used in pumps, filter wires, and for the steam piping within the digester.

The kraft or sulphate process differs from the sulphite process in two very marked ways. The first and more usually understood difference is the alkaline nature of the cooking liquor in the kraft process as against the acid nature of the cooking liquor in the sulphite process.

The second important difference is the fact that the kraft process must be able to recover a greater proportion of the chemicals used in the digester, regenerate them to cooking liquor and use them over. The chemicals used are too expensive to dump down the sewer, and unless they can be recovered and regenerated economically the kraft process cannot be operated profitably. In the sulphite process the liquor is discarded after blowing the digester and no attempt is made to salvage chemicals other than relief gases, because they are cheaper than cost of their recovery. Another point that goes along with the regeneration of the chemicals in the kraft process is the recovery of the heat as steam and hot water.

The kraft process can pulp almost any kind of wood, including both hard and soft woods. The soft woods used at Camas are hemlock, white fir and some spruce. The hemlock is the denser wood and requires the larger amount of chemicals for cooking. White fir and spruce are nearly the same density and require the same chemical charge. The woods are cooked separately but are all blown into the same tank.

Cooking Operation

The five Kellogg 10x26 foot kraft digesters at Camas are the tumbling or rotary type. Three of them have through shafts and two of them has the trunnions bolted to the shell. The digesters require about four minutes for one revolution. The chips are stored in chip bins located directly overhead. One end of the digester is capped with a heavy steel cover held in place by bolts. When a digester is to be filled the shell is turned into a vertical position, the cover removed, and the chips and cooking liquor run in together. Running the cooking liquor and chips in together cuts down the filling time. The liquor is run out of a calibrated tank with a gauge glass on the side which enables the operators to measure accurately the amount

of liquor added to each digester. After the chips and liquor are in, the cover is bolted in place and the steam valve opened.

Fig. 51
Kraft Digesters



The digester is rotated for fifteen or twenty minutes, then stopped with the cover down, the gas-off hose connected and the gas-off valve opened. This valve is left open until all of the cold air or gas is withdrawn, usually requiring about fifteen or twenty minutes. The digester is then started rotating again. The steam is left on until the pressure reaches about 120 pounds. The digester is rotated about thirty minutes more, then stopped with the cover up. The relief valve is opened and the pressure brought down to 80 pounds. The relief gases go out through the steam coil in the top of the digesters which connects to the relief line going into the blow tank. In the meantime the bottom helper has withdrawn a sample of the pulp through the gas-off valve in the bottom of the digester. This is passed up to the cook who examines it, and if the pulp is satisfactory, the bottom helper opens the blow valve and the pulp is blown out through the blow line into the top of the blow tank. The pulp and black liquor drop to the bottom of the tank and the steam and gases formed during the cook pass out through a spray condenser and thence to the sewer. During the blow the relief valve is left open until the pressure is down to 50 pounds. The closing of the relief valve at this point insures enough pressure to blow the remainder of the stock out of the digester.

The time for bringing the digester to pressure is about one hour and time held at pressure about thirty-five minutes, or a total cooking time of about one hour and thirty-five minutes. The total cooking cycle from fill to fill is two hours; this allows twenty-five minutes for filling, capping, uncapping and blowing the digester.

At the present time a device for automatic cooking is being developed. This will bring each cook to pressure in the same length of time and at the same rate thus eliminating one of the variables in cooking.

Stationary Digesters

The use of stationary digesters in kraft pulping is also common practice. They generally have a capacity of about eight tons and are usually equipped with heaters for indirect heating of the cooking liquor. Cooking time is usually about three hours.

The digesters are usually smaller in diameter in proportion to the height than is the case with rotary digesters. The bottoms are generally conical with the top dish shaped. The conical bottom gives less trouble in blowing than the dish-shaped bottom.

The use of heaters and circulating pumps on stationary digesters permits the recovery of condensate from the cooking steam and a shorter cooking time.

Blow Tank and Pump

The blow tank into which the pulp is blown is an iron vessel about 35 feet high and 12 feet in diameter. It has an agitator on a vertical shaft which extends up from the bottom of the tank. The purpose of this agitator is to mix the stock with the diluting black liquor added here. Diluting liquor must be added to the stock in the blow tank in order to make it low enough in consistency to pump. The stock coming from the digester has a consistency of about 15 percent. Enough weak black liquor is added in the blow tank to bring it down to about 7 percent, at which consistency the plunger pump can handle it. The plunger or triplex pump takes the stock from the blow tank and pumps it to a Warner equalizer located ahead of the primary washers. More weak black liquor is added at the triplex pump so that the consistency going to the equalizer is about 3 percent.

Gases from the blow tank contain methyl mercaptan and dimethyl sulphide, the compounds largely responsible for the characteristic kraft mill odor. The gases for this reason are discharged under water so the objectionable odoriferous elements can be absorbed as much as possible. Methyl mercaptan is formed by sulphur replacing oxygen in the methyl alcohol by-products formed in the cooking operation.

Warner Equalizer

The Warner equalizer brings the consistency down to between $1\frac{1}{2}$ and 2 percent, depending on the adjustment of the liquor valve in the bottom of the equalizer. This consistency is determined by the amount of stock left in the blow tank and how the washers are working. The equalizer consists of a cylinder about 6 feet high and 3 feet in diameter. It is equipped with a motor driven agitator whose blades are connected to the shaft through a spring. As the stock gets thicker the blades are harder to turn

in the stock so they transfer this tension to the spring, which in turn actuates a lever that opens the valve letting more liquor into the stock.

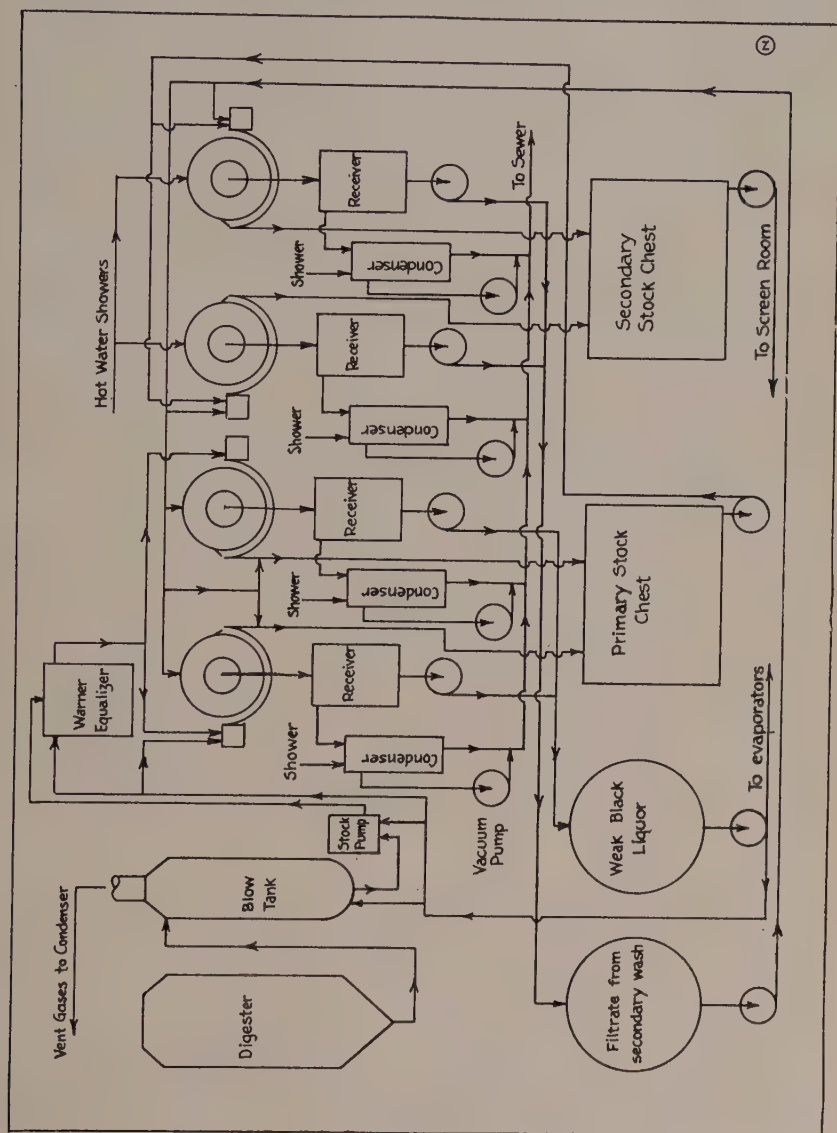


Fig. 52 Flow Sheet of Kraft Washing System

As the stock gets thinner the spring tension becomes less and the valve cuts off some of the liquor. The stock flows from the equalizer through pipes to the head boxes of the primary washers.

Washing System

The pulp washing is done in a counter-current two-stage system using vacuum washers. The first washing, or primary stage, has one 6x6 foot and one 6x10 foot Oliver washer. The second washing, or secondary stage, has one 8x8 foot Impco washer and one 6x6 foot Oliver washer.

When the stock enters the headbox of the primary washers, after leaving the equalizer, it is further diluted by more weak black liquor. The vacuum applied to the drum of the washer pulls the black liquor through the pulp sheet. Weak filtrate from the secondary is also sprayed on to the sheet. This penetrates the sheet and displaces the strong black liquor. The liquor pulled out of the pulp by the vacuum applied to the sheet is pumped to the weak black liquor storage tank and from there to the evaporators. It is important that the weak wash liquor merely displace the strong liquor with minimum dilution in order to reduce the amount of evaporation necessary. In the secondary stage fresh hot water is used as the wash liquor. Weak black liquor is used for dilution liquor in the vat and headbox of the primary washers and filtrate from the secondary stage is used as slushing water for the stock leaving the primary washer. There are always approximately 1100 gallons per minute of weak black liquor being circulated through the secondary stage. The pulp leaves the secondary stage at 20% consistency. As it drops into the stock chest enough weak filtrate is added so that the consistency is brought down to $3\frac{1}{2}\%$. The stock is pumped from the chest to the headbox of the secondary washers where it is washed with fresh water. After it leaves the secondary washers it is slushed up with fresh water and pumped to the screen room where it is given another washing before going over the knotters and deckers. Mixing of air with the liquor in vacuum washing is avoided as much as possible so as to minimize foaming.

Other Types of Washing Systems

The washing system just described is a fairly recent development. Most kraft mills use diffusers for washing the pulp. Diffusers usually have about 10 to 20 percent greater volume than the digesters. At the top there is an opening which affords an entrance for the stock and an outlet for the escaping steam. The digester is blown directly into the diffuser. Common practice is to have a battery of diffusers and to blow into each diffuser in rotation. The wash liquor enters one diffuser as fresh water and proceeds from one diffuser to another, each containing a cook that is not quite as well washed as the preceding one, until the liquor is finally strong enough to be sent to the evaporator.

Evaporators

The function of the evaporators is to remove water, or concentrate the black liquor that is separated from the pulp in the washers to such a density, that when it is sprayed into the recovery furnace it will ignite and burn because of the organic matter it contains. At Camas this concentration is done in two types of evaporators, (a) multiple effect steam evaporators, and (b) direct heat or disc evaporator utilizing the hot gases from the furnace.

Multiple Effect Evaporators

A multiple effect evaporator consists of several units, or effects, connected in series by means of vapor piping in which the water vapor boiled off the liquor in the first effect acts as the heating steam in the steam chest of the second effect. Here it gives up its latent heat to the vapor going to the third effect and so on to the last effect whose vapors go to a condenser. Each effect may be considered as a surface condenser for the preceding effect. In this way an amount of evaporation and heating that is equivalent to the latent heat of the steam supplied to the first effect is obtained in each effect of the evaporator. The result is that one pound of steam supplied to the evaporator vaporizes an increasing amount of water as the number of effects is increased.

The Black liquor is drawn from the storage tank by pumps to effects VA and VB, Fig. 53; it is transferred from VA and VB to IVA and IVB by pumps, and by pumps on up to IIA and IIB. From there it is pumped into a storage tank. The liquor enters at about 10.3° Baumé or 14% solids and leaves the Zarembas at 21° Baumé or 28% solids. This partially concentrated black liquor is drawn from the storage tank by a pump and forced through a heater where the temperature is raised from 212° F. to about 252° F. From the heater it goes to a Swenson concentrator. The boiling point in the concentrator is about 250° F. so the liquor immediately starts to boil without any preliminary heating.

Float valves on the feed to each effect control the liquor levels so that the tubes are barely covered thus insuring maximum efficiency.

Steam is supplied to the steam chest of the concentrator at about 40 pounds pressure and to the heater at 120 pounds pressure. The condensate from both heater and concentrator goes to the boiler feed hot well. The vapors from the concentrator go to effects IIA and to IIB. The vapor from IIA goes to the steam chest of IIIA and the vapors from IIIA to the steam chest of IVA and the vapors from IVA go to the steam chest of VA. The vapors from VA go to a barometric condenser where they are condensed and sent to the sewer. The condenser is equipped with a steam jet air

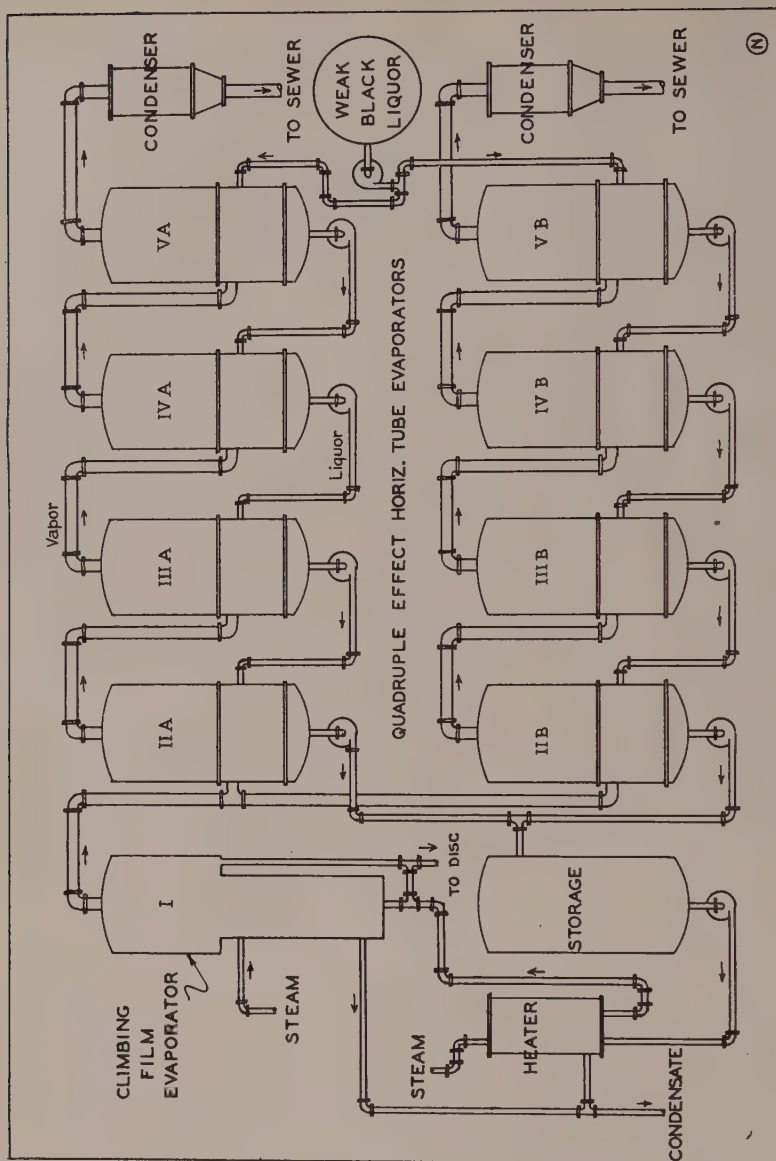


Fig. 53

Diagram Showing Flow of Black Liquor and Steam in Multiple Effect Evaporators

ejector for removing air and non-condensable gases. The steam chests of all the effects are equipped with vent lines to the condenser for removing non-condensable gases from the vapors. The condensate from IIA and IIIA

is combined and flashed into the steam chest of VA along with the condensate of IVA. The condensate from VA is taken by a pump to the sewer. The vapor from IIB goes to the steam chest of IIIB, from IIIB to IVB to the steam chest of VB, and from VB to another barometric condenser. Condensate goes in the same order as in the A set.

The liquor leaving the Swenson concentrator is about 33° Baumé or 48% solids; it passes directly from the concentrator to the disc evaporator where its solids content is further increased.

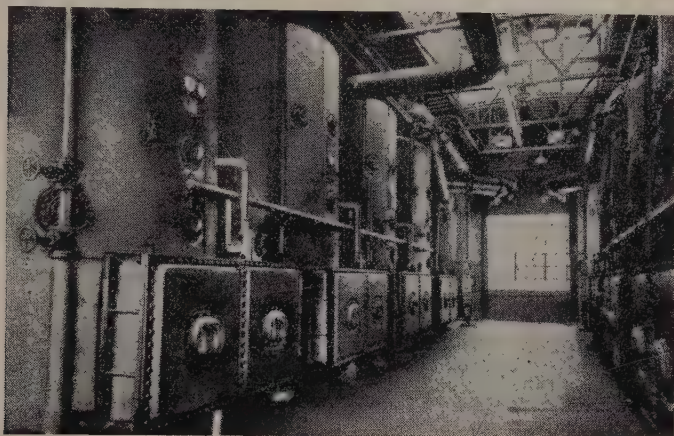


Fig. 54 Zaremba Quadruple Effect Evaporators

Construction of the Evaporators

The first evaporator effects are **Zaremba horizontal** submerged tube evaporators. In these the tubes are horizontal with the steam inside them and the liquor outside. The liquor enters just above the tubes and is withdrawn at the bottom by a pump and fed to the next effect. A large vapor space above the tubes allows entrained liquor to separate from the vapor. There are two sets of these evaporators both constructed the same except for size. The large set has 2540 sq. ft. of heating surface per effect and the small set has 1350 sq. ft. of heating surface per effect.

The last effect of the evaporators, the **Swenson Concentrator**, is a vertical long tube film type evaporator. In this evaporator the steam is on the outside and the liquor inside the tubes. The liquor enters at the bottom and as soon as it hits the hot surface of the tubes it starts to boil. This carries it along in the form of foam and bubbles that produce a high velocity filming action on the heating surface. Across the top of the tubes there is a steel umbrella against which the liquor impinges and the vapor separates and goes on out the vapor line. The liquor flows down through a

10-inch pipe through a flash tank and then to the disc evaporator. This last effect has 970 tubes $1\frac{3}{4}$ " in diameter and 16 feet long. The total heating surface is 6050 square feet. About 75% of the total liquor evaporation occurs in the Zarembas.

Other Types of Evaporators

In most of the new Southern mills all effects of the evaporator are long tube vertical film type. In these the liquor is usually brought up to the required strength without the further evaporation as obtained in a disc evaporator.

Some mills instead of using a disc for the final concentration, use what is known as a "high speed body." In this, a circulating pump carries the liquor over the tubes at a high velocity. Heating surfaces are usually smaller because of the high rate of heat transfer obtained by the high velocity over the tubes. Steam of about 150 pounds pressure is generally used and vapor taken off at around 50 pounds.

Other types of evaporators used are the Buffalo natural circulation evaporator and the Peebles evaporator. In the Buffalo, the liquor circulates around through a circulating leg outside the evaporators the same as the discharge pipe in the Swenson Concentrator. In the Peebles, the liquor enters the top of the evaporators and falls in a thin film down the inside of the tubes and is taken out the bottom.

The liquor after leaving the Swenson concentrator passes to the **disc evaporator**. This evaporator consists of a number of steel discs $8\frac{1}{2}$ feet in diameter mounted on a horizontal shaft. A motor turns this shaft slowly causing the discs to revolve in the pool of liquor on the bottom. The liquor sticks to the discs and the hot gases from the furnace pass over it and evaporate some of the water. The concentration of the liquor is raised from 33° Baumé or 49% solids to 37° or 57% solids. In our case the disc evaporator utilizes heat that would otherwise go out of the stack or be used in evaporating water in a spray tower. However, if a mill is so equipped that it can recover this heat in the form of steam it is better to do it that way, because the thermal efficiency of the disc is very low. In our case steam is generated at 150 pounds pressure. The feed water enters the boiler at 200° F. The heat necessary to evaporate one pound of water under these conditions is about 887 B.T.U. When this steam is used in the multiple effect evaporators about 3.3 pounds of water are evaporated from the black liquor for every pound of steam used. In other words, for every B.T.U. supplied by the furnace in the form of steam we get the equivalent of 3.7 B.T.U.'s of evaporation in the vacuum type evaporators.

In the disc evaporator, water from the black liquor is evaporated at

180° F. This requires 990 B.T.U. for one pound of evaporation. This steam must then be heated to 250° F., the exit temperature of the gases from the disc. This requires an additional 35 B.T.U., making a total of 1025 B.T.U.'s necessary. In other words, for every B.T.U. supplied to the disc as heat in the gases instead of steam to the evaporators we get only the equivalent of 0.86 B.T.U. of evaporation. Another way to put it is that it takes 4.3 times as much heat to evaporate one pound of water in the disc as it does in the multiple effect evaporators.

The liquor after leaving the disc is pumped to storage tanks and from there to the Tomlinson furnace.

Recovery Furnace

Before going to the furnace the liquor has to be heated from 180° F. to 210° F. This is done in a heater after the liquor leaves the strong tanks. This heater is exactly the same as the one used just ahead of the Swenson evaporator. The strong liquor after leaving the heater goes to a mixing tank where the salt cake is added from a screw conveyor fed from a hopper having an automatic feed which can be set to admit any amount desired. The salt cake drops into the mixing tank and is thoroughly mixed with the liquor by means of a circulating pump. The liquor is then pumped from this tank to the recovery furnace spray.

The Tomlinson recovery furnace is a new and recent installation at Camas displacing three of the old type rotary furnaces. It is rectangular in design, about 30 feet high and 15 feet square. The walls are built entirely of water tubes with a light coating of plastic chrome refractory cement. The water walls on all four sides of the furnace are connected into mud drums at the bottom and into headers at the top which are so connected to the boiler drums that boiler water is circulated continuously through the walls. In this way the furnace really becomes a part of the waste heat boiler. The side water walls are carried under the hearth to a central mud drum and serve to cool the refractory used to build up the sloping hearth of the furnace. At the back and top of the furnace is a throat about six feet long and six feet square which connects the furnace or combustion chamber with the waste heat boiler. This throat is also made up of water tubes covered with chrome cement.

The boiler is a three drum single-pass waste heat boiler capable of generating 70,000 pounds of steam an hour at 150 pounds pressure. This is in contrast to heat recovery and steam generation with the former rotary furnaces, where about 12,500 pounds per hour were made. The increased steam recovery is one of the chief advantages of the Tomlinson type of furnace. Prior to it, the Kraft mill "bought" a lot of steam from the steam plant; now there is practically no outside steam used. The Tomlinson

supplies enough steam for cooking and for heating water for pulp washing.

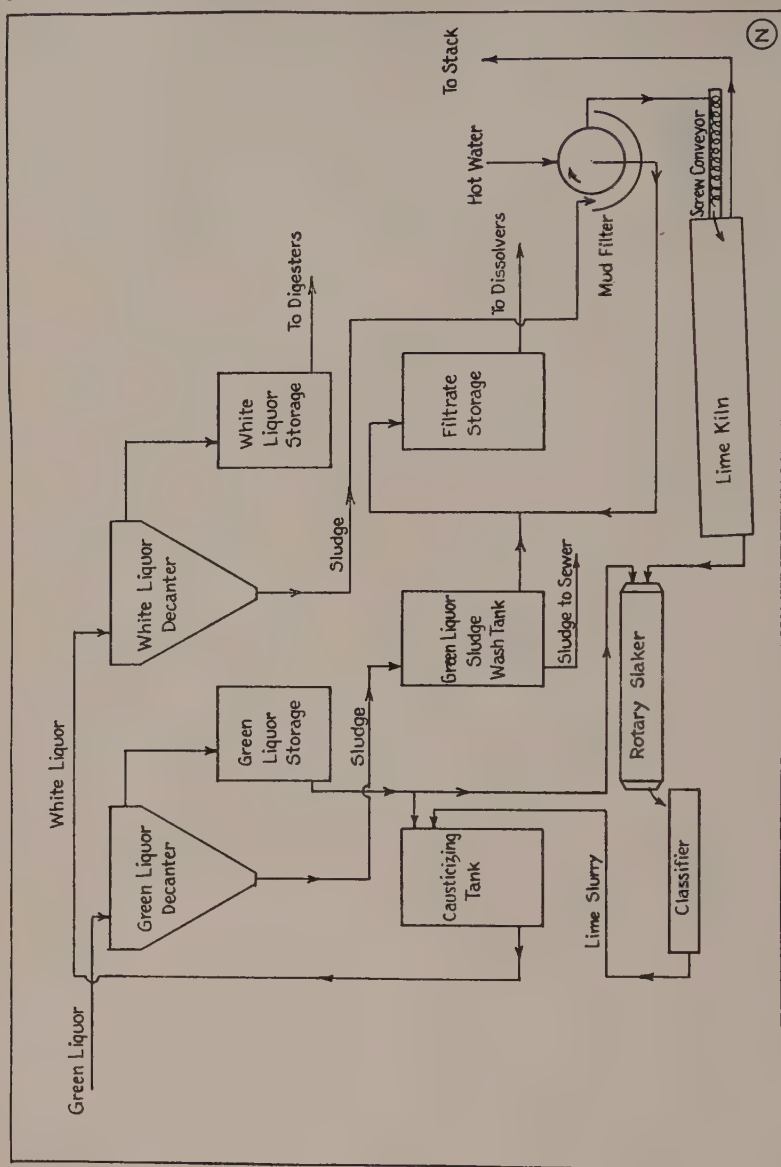


Fig. 55 Liquor Causticizing Flow Sheet

Air is supplied to the furnace through about thirty primary air nozzles located about three feet above the hearth and through a like number of secondary nozzles located about fifteen feet above the hearth. A centrifugal

blower supplies the air which passes through an air heater before going to the furnace. This heater is located at the back of the boiler and raises the air temperature to about 410° F. The amount of air is controlled by raising and lowering dampers in the nozzles and also by the pressure the blower generates. Excess air is avoided as this will oxidize carbon directly to carbon dioxide thereby destroying its ability to reduce salt cake to sodium sulphide. Incomplete salt cake reduction tends to upset the sulphide-sulphite balance in the digester toward formation of certain organic sulphur compounds causing malodor in kraft paper.

The spray nozzle is given an oscillating motion which sprays the back and side walls of the furnace with liquor. The liquor in passing through the chamber is partially evaporated so it is in the form of large sticky drops when it reaches the walls. These drops stick to the walls and are further dried out. This gradually builds up a char on the walls which falls into the hearth where it is burned.

The hot gases from this burning organic matter pass out through the furnace throat through the boiler and air heater through the disc evaporator, then to an induced draft fan, through a spray tower and then to the stack. The furnace gases leave the air heater at 410° F., are cooled to 250° F. in the disc evaporator and to about 160° F. in the spray tower. When they leave the spray tower they are at the dew point so in order to prevent damage to the stack the gases from the lime kiln are introduced into the stack thus raising the furnace gases above the dew point.

During the burning of the char on the hearth of the furnace, the caustic soda which was combined with the organic matter in the black liquor is converted mainly to sodium carbonate or soda ash. The salt cake or sodium sulphate that was added to the black liquor before burning is converted to sodium sulphide. Enough salt cake has to be added continually to make up for soda and sulphide lost in the cycle. It is the presence of sodium sulphide in the kraft cooking liquor that differentiates the kraft process from the soda process. Innumerable reactions occur at this stage of the recovery process, but the two main ones may be represented by the following equations.



(Soda combined with organic matter of black liquor plus burning gives soda ash plus heat plus exit gases.)



(Salt cake burned with black ash gives sodium sulphide and exit gas of carbon dioxide.)

In equation 1, R is an organic radical. In equation 2, the salt cake Na_2SO_4 is being converted to sodium sulphide Na_2S .

As the burning of the ash and these reactions proceed the smelt, consisting of melted sodium sulphide and sodium carbonate, runs out the front of the hearth through a water cooled spout into a dissolving tank full of water there forming "green liquor."

Causticizing Operation

When the green liquor reaches a certain strength, as determined by tests made by the caustic room operator, it is pumped to two green liquor decanters. These decanters are large cone-shaped tanks, 24 feet in diameter, each with a capacity of 5700 cubic feet. The unburned carbon and other impurities settle out and the clear green liquor is siphoned off the top into storage tanks. The sludge that settles in the decanters is drawn off the bottom into wash tanks where it is given four washes in order to remove the soda in it and is then sent to the sewer. The wash water is used as make-up water in the dissolvers.

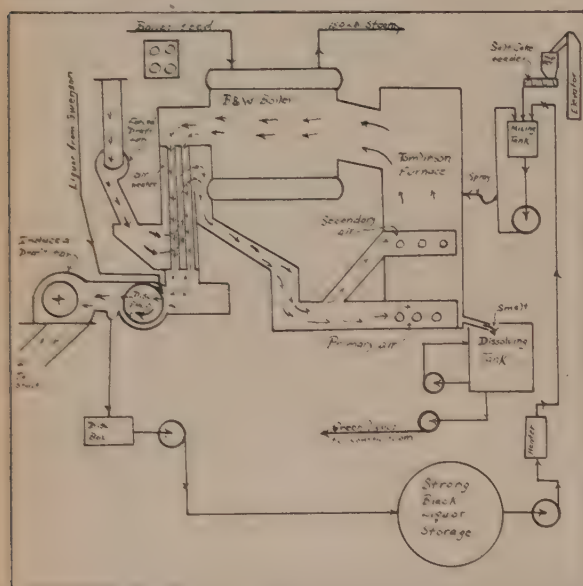


Fig. 56.
Flow of Liquor and Gases
Through Tomlinson
Furnace

Half of the green liquor is pumped from the storage tanks into the slaker and half directly to the causticizing tanks. Lime and green liquor are added together at the feed end of the rotating slaker and flow to the discharge end. The slaked lime flows down a trough to the classifier where all the underburned and overburned cores are removed along with any sand and other foreign matter.

The lime slurry is then pumped to the causticizing tanks where the balance of the green liquor is added. The green liquor and lime slurry are added at the bottom of one causticizing tank, overflow from it to the second one and the resultant mixture of sludge and white liquor pumped continuously from it to the white liquor decanters.

Reactions occurring during the operation may be represented by the following equation:



(Soda ash plus lime, all in water, gives caustic soda solution and calcium carbonate which settles out.)

As can be seen from this equation, two products are formed: sodium hydroxide NaOH and calcium carbonate CaCO_3 . The sodium hydroxide is the active cooking agent, along with the sodium sulphide. The sodium sulphide carries through the causticizing operation unchanged.

In the white liquor decanters the lime mud settles to the bottom of the cone and the clear white liquor is siphoned off into storage tanks and then pumped to the digesters as needed.

A good quality of white liquor will contain:

Sodium Carbonate.....	15%
Sodium Hydroxide.....	57%
Sodium Sulphide.....	28%

The dissolving action of the white liquor on the wood is due to the sodium hydroxide (caustic soda) and the sodium sulphide. The sodium carbonate (soda ash) is inactive in the cooking process. A white liquor high in sodium sulphide content is a very important factor in producing pulp of high strength and quality. If the liquor is low in sodium sulphide content the cooking action resembles that of the soda pulp process producing a low strength pulp typical of soda pulp. The yield in the kraft process is about 10% higher than in soda pulping due to its less drastic dissolving action.

Lime Kiln

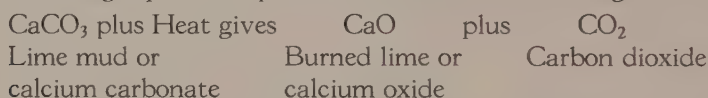
Lime mud is withdrawn from the bottom of the decanters by pumps and sent to two Galmorgan 6x3 foot vacuum filters. These operate on the same principle as the vacuum pulp washers and consist of two units operating in series with the wash water flowing countercurrent. On the primary washer filtrate from the secondary stage is used as wash liquor and fresh water is used on the secondary stage. The mud from the secondary stage drops down a chute onto a screw conveyor which transfers it to the back end of the oil-fired rotary kiln 100 ft. long x 7 ft. inside diameter.

The kiln rotates at about one-half R.P.M. and is sloped toward the front end. The mud gradually rolls down toward the front of the kiln, being "burned" by the intense heat, finally emerging as "reburned" lime and is then used again for causticizing. This lime recovery is essential to economical operation. During the early days of sulphate pulping, lime mud was dumped and new lime used.

Kiln operation is controlled by a revolving radiation pyrometer in the front end and a recording thermometer in the back end. A recording conductivity meter on the filtrate from the mud filters gives the amount of soda left in the cake going to the kiln. It is important that this be kept within certain limits otherwise "ringing" of the kiln occurs.

By "ringing" is meant the tendency for the lime mud entering the kiln to stick to the walls of the kiln in the form of rings which keep the kiln from producing lime. Prior to the installation of the slaking and classifying equipment considerable trouble was experienced with this but with clean lime sludge now absolutely free of underburned lime, overburned cores, and other foreign matter, no trouble is experienced. Before this equipment was installed the slaking and causticizing were done in the same tank and the resultant slurry pumped to the decanters without any attempt being made to remove impurities.

The following equation represents the reaction occurring in the kiln:



Between 80% and 90% of the lime used in causticizing is recovered through the kiln and reused. The balance of the usage is made up with new lime.

This operation completes the chemical cycle of the kraft process.

Summary of Process

"White" liquor is converted to "black" liquor in the cooking process of dissolving the lignin, or cementing material, from the fibers or cellulose. This black liquor, containing most of the chemicals, is concentrated in the evaporators and burned in the furnace recovering the chemicals in the form of soda ash and sodium sulphide which are dissolved in water becoming "green" liquor. The soda ash is converted to caustic soda by means of lime which changes the "green" liquor to "white" liquor. The "white" liquor, now a solution of caustic soda and sodium sulphide, is used over again as cooking liquor. The lime mud formed during the causticizing process is converted in the kiln to quicklime and then used over again in the causticizing operation.

Control of the Operation

The operators make most of the tests that are used in controlling the operation of the mill from hour to hour.

The white liquor used in each cook has to be tested in order to determine the amount to add to the digester. The washer operators govern the addition of fresh water to the washers by Baumé tests on the liquor leaving the washers. Steam flow and liquor flow to the evaporators are regulated according to Baumé tests on the liquor entering and leaving the evaporators.

The pumping of the dissolvers, the addition of lime to the slaker and green liquor to the causticizing tanks are all governed by tests on the liquor. Operation of the mud filters is also governed by tests made by the operators on the filtrate.

The foregoing tests are all simple and easy to perform. The more complicated analyses made on the green liquor and reburned lime are made daily in the laboratory by a trained chemist. From these analyses the kiln and furnace efficiencies are determined. Tests on the washed pulp leaving the kraft mill are also made daily to determine the soda left in the pulp.

In addition to the daily tests a chemical balance is made every week on both the soda recovery system and lime recovery system. Recording conductivity meters in the sewers enable an accurate check to be kept on the soda lost to the sewer. A heat balance on the whole mill is also computed along with one on the evaporators and furnace. Typical weekly and daily report forms are included in this chapter.

SUMMARY OF KRAFT MILL OPERATION

For Week Ending _____

PULP PRODUCTION

No. of Cooks _____

No. of Tons _____

SALT CAKE USAGE AND RECOVERY

Salt Cake added _____

Na_2SO_4 in system last week _____

Na_2SO_4 in system this week _____

Inventory gain _____

Na_2SO_4 lost from system _____

Na_2SO_4 to digesters _____

Na_2SO_4 recovered _____

Percent recovery _____

SEGREGATION OF LOSSES

Washing Losses: _____
Pulp Losses _____ Lbs. per Ton

Sewer Loss from Nos. 1, 2, 3 Washers _____

Sewer Loss from No. 4 Washer _____

Sewer Loss from Weak Filtrate Tank _____

Total Washing Loss _____ Lbs. per Ton

Caustic and Recovery Room Losses _____ Lbs. per Ton

Stack Loss _____ Lbs. per Ton

Total Salt Cake Loss _____ Lbs. per Ton

CAUSTIC ROOM OPERATION

Lbs. Fresh Lime Used _____

Lbs. per Ton of Pulp _____

Total Lime Used _____

Kiln Output _____

Percent Recovery _____

Gallons Oil Used _____

Lbs. CaO per Gallon of Oil _____

Barrels Oil per Ton of CaO _____

EVAPORATOR OPERATION

Density Liquor to Zarembas	_____
Density Liquor from Zarembas	_____
Density Liquor from Swenson	_____
Density Liquor from Disc	_____
Tonnage Rate	_____
Evaporation A Set—Lbs. per hour	_____
Evaporation B Set—Lbs. per hour	_____
Evaporation Swenson—Lbs. per hour	_____
Evaporation Disc—Lbs. per hour	_____
Lbs. Steam to Swenson per hour	_____
Lbs. Steam to Heater per hour	_____
Evaporation per Lb. Steam	_____
Lbs. Steam to Furnace Heater per hour	_____

TOMLINSON FURNACE

Tonnage Rate	_____
Steam per Ton	_____
Percent Solids to Furnace	_____
Reduction	_____

STEAM DISTRIBUTION

Developed by Tomlinson	_____	
Purchased from Steam Plant	_____	Lbs. per Ton
Total Usage	_____	Lbs. per Ton
Used in Cooking	_____	Lbs. per Ton
Used in Evaporation	_____	Lbs. per Ton
Used in Heating	_____	Lbs. per Ton

SOLIDS PER TON OF PULP

Ton Pulp	_____
Lbs. Black Liquor Produced	_____
Lbs. Solids Produced	_____
Solids per Ton	_____

KRAFT MILL

GREEN LIQUOR Composite Analysis

COOKING LIQUOR Average Analysis

REBURNED LIME Composite Analysis

Total Na ₂ O _____	Total Na ₂ O _____	CaCO ₃ — % _____
Active Na ₂ O _____	Active Na ₂ O _____	Active CaO — % _____
Na ₂ S as Na ₂ O _____	Na ₂ S as Na ₂ O _____	Inert — % _____
Na ₂ SO ₄ as Na ₂ O _____	Iron and Alumina (R ₂ O ₃) _____	Na ₂ CO ₃ — % _____
Na ₂ SO ₃ as Na ₂ O _____	Silica (SiO ₂) _____	Iron & Alumina (R ₂ O ₃) _____
Sulphidity % _____	Activity _____	Silica (SiO ₂) _____
Reduction % _____	Sulphidity _____	Conversion % _____

LIME MUD Composite Analysis

Classifier Rejects Composite Analysis

Pulp Washer Operation

Free Lime (CaO) _____	Free Lime — % _____	Soda Loss in Lbs. per Ton pH at _____
Soda (Na ₂ O) _____	Soda — % _____	Shift Na ₂ O Na ₂ SO ₄ Deckers _____
Moisture — % _____	Moisture — % _____	6-12 N _____
		12-6 PM _____
		6-12 MN _____
		12-6 AM _____
		Average _____
		Total _____
		Na ₂ SO ₄ Lost _____

Wood Usage

Chemical and Fuel Oil Usage

Cooks Hemlock _____	Starch _____
Cooks White Fir _____	Soda Ash _____
Cooks Spruce _____	Salt Cake _____
Total Tons Pulp _____	Nitre Cake _____
	Lime _____
	Fuel Oil to Kiln _____
	Fuel Oil to Furnaces _____
	Total Oil _____

REMARKS: _____

Compiled by _____

CHAPTER VIII

MANUFACTURE OF SULPHITE PULP

By J. G. LONG

Brief History of the Industry

The first record of any process resembling the present sulphite process appears to be a patent issued to Julius A. Roth in 1857 for the treatment of wood with sulphurous acid. However, credit is usually given to B. C. Tilghman, who conducted tests at the W. W. Harding & Sons paper mill in Manyunk, Pennsylvania, on cooking of wood with sulphur dioxide solution in the presence of a calcium base, which process was patented in 1866. It is interesting to note that Tilghman was farsighted enough to attempt to make his process a continuous one by using a rotary digester 50 feet long by 3 feet in diameter. After operating on a batch system for so many years, engineers are now giving considerable attention to the possibilities of continuous pulping as attempted by Tilghman. Tilghman's attempts did not meet with success due to mechanical conditions and market difficulties and was finally abandoned. It remained for a Swedish chemist, C. D. Ekman, to put the process on a commercial basis by constructing a mill at Bergvik, Sweden, in 1874, including six small 800 pound steam jacketed rotary digesters. In 1880, a German chemist, A. Mitscherlich, developed a similar process but cooked for longer periods with copper steam coils in stationary digesters. At about this time, E. Ritter and C. Kellner developed the direct steaming process which shortened the cooking time considerably. The Mitscherlich system was introduced into this country in 1887 by A. Thilmany and was first operated by the International Fiber and Paper Company in Michigan. The Ritter-Kellner system was introduced by Charles Riordan at Merriton, Ontario, in 1885.

Digester Construction

The men who first worked on the commercial development of the sulphite process had their greatest problem in designing and building a cooking vessel or digester. The digesters in use at the present time are the result of many improvements made over a period of years but the design and basic methods used are practically the same for all installations of recent date. The digesters are shaped like a fat cigar, the height being approximately three times the diameter.

Fig. 57 shows a battery of sulphite digesters in a Pacific Coast mill

erected before the building was constructed and gives an excellent idea of the proportions and type of riveted construction.



Fig. 57 Erecting Sulphite Digesters

The digester shell is made of boiler plate which has been rolled and punched in the shop and assembled and riveted on location. The boiler plate used is from an inch and one-eighth to an inch and seven-eighths in thickness, depending on the size of the digester. The steel shell must withstand normal operating pressures of 100–125 pounds per square inch and still have a high safety factor.

When a new digester is being built the shell is first assembled and erected in place. Then before any of the fittings are attached, the shell is filled with cold water and subjected to a pressure of at least 150 pounds per square inch. This hydraulic test detects seam and rivet leaks which are then

caulked. It also extends the shell against all slackness in the rivets, so no further movement will take place after the lining has been installed. It is customary also to apply a steam pressure test to check temperature expansion leaks. The fittings which attach to the digester shell are then put in place, these being pockets or sleeves for thermometer wells, etc. The number of fittings attached directly to the shell of the digester is limited as much as possible, though some of these are absolutely necessary. All digesters have at least one thermometer fitting, one pressure plug fitting, one sampling cock fitting and one side relief fitting. Some digesters have additional thermometer fittings and sampling cock fittings.

The method for attachment of each of these fittings is practically the same. The shell must first be cut to admit an acid resisting sleeve, and the shell reinforced at this point where it has been weakened. The sleeve is cast with a shoulder which rests against the inside surface of the shell. The end of the sleeve which protrudes through to the outside of the shell is threaded to receive a lock nut. When this nut is drawn up tight, the shoulder on the sleeve within the shell is drawn firmly against the shell, the sleeve being held in position by this means.

Digester Lining

Since steel is very susceptible to attack by the cooking acid some protective lining is absolutely necessary. In the early days attempts were made to use lead but the differences in expansion of the lead and the steel as the temperature of the vessel increased during the cook caused the lead lining to pull away from the shell. The results were far from satisfactory.

All modern digesters are lined with an acid-resisting brick. The brick lining also acts as an insulating material to prevent the heat of the acid being transferred to the steel shell during the cook. The thermal expansion of the brick lining is considerably less than that of the steel shell, so if the lining and shell both attained the temperature of the cooking acid in the digester the steel shell would expand away from the lining. However, the thickness of the lining is carefully designed to provide a definite amount of thermal insulation to the shell. In this way the temperature of the shell is held so low that it expands at a uniform rate with the lining.

When the steel work of the shell has been completed it is thoroughly cleaned in preparation for installation of the lining. All grease and other foreign material is carefully removed from its interior surface. A bronze or stainless steel sleeve is placed in position at the apex of the bottom cone of the digester. Brick masons who specialize in this work then start the installation of the lining from this sleeve. The lining is made up of a series of layers, the first being the grout placed against the shell, the next a layer

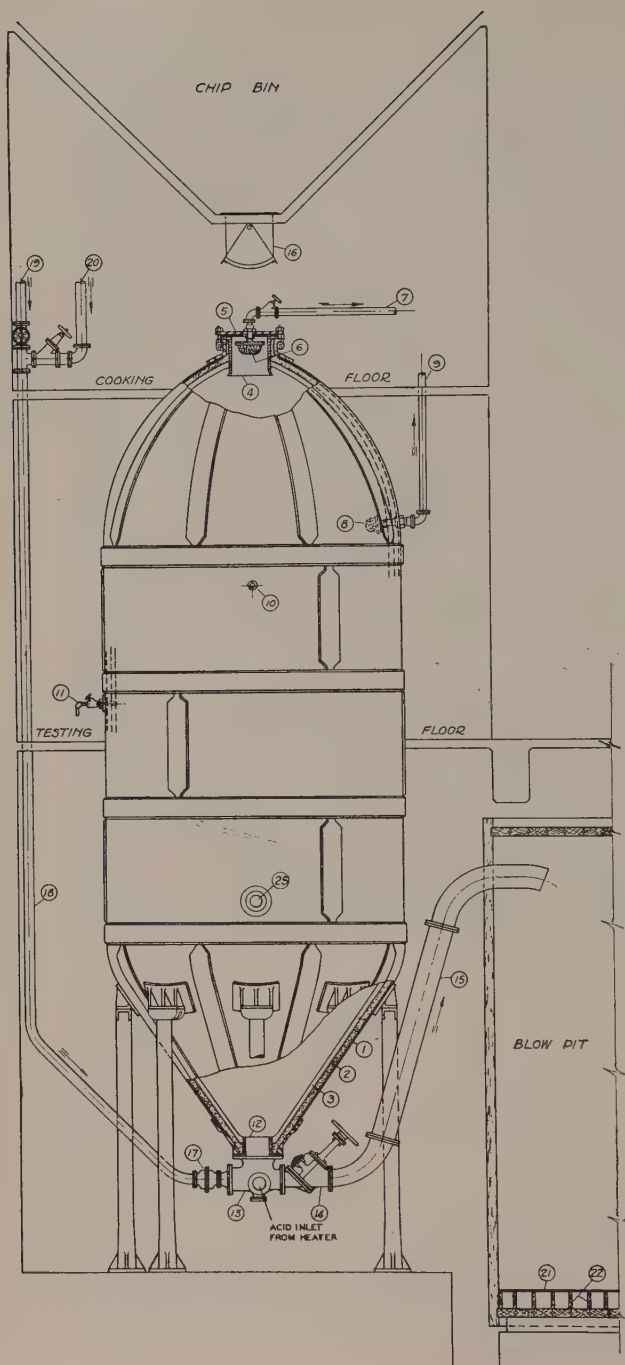


Fig. 58
Digester
Construction

of acid-resisting brick, then a second layer of grout and finally a second layer of acid-resisting brick. Special shaped brick are required for domes

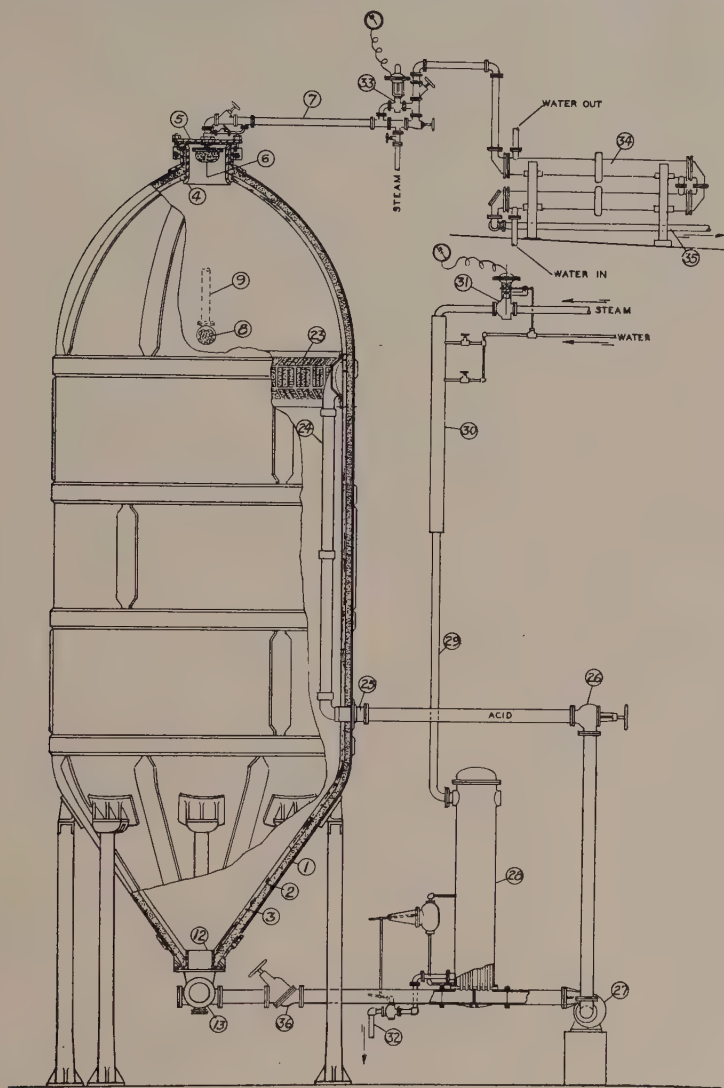


Fig. 59 Digester Circulating System

and cones and around top and bottom sleeves. The overall thickness of the lining is $7\frac{1}{2}$ inches. The grout is poured in place in the form of a very thin slurry. The acid-resisting brick are set in place with a special mortar made

with litharge and glycerine, which is resistant to the action of the acid. A great deal of skill and care is needed in making the installation free of fine hair seams which quickly open up after the lining is in service. When the lining is installed, careful attention must be given to make a tight joint at each sleeve. Ordinarily, the length of the sleeve is adjusted to the thickness of the lining both, being flush when the lining is completed.

When the lining is first installed it is not moistureproof. The brick are somewhat porous and even if all the seams and mortar joints are tight a small amount of moisture will penetrate the body of the brick. Few linings are absolutely dry at the shell of the digester. In many instances, if a test hole is drilled through the shell to the lining it will be found that a small amount of liquid will collect and run out. When the lining is first placed in service the acid penetrates the brick, but a deposit of lime and other material is gradually built up in the pores of the brick, and after a period of a few months most of this penetration stops. In passing through the brick the active constituents of the acid are absorbed and the moisture which reaches the surface of the shell is no longer corrosive. However, if a fine hair seam in the mortar permits direct entrance of the acid into the lining, a different action results. During successive cooks the acid is forced into the fine seam during the period of the cook and then works out when the pressure is relieved on the digester. This slightly surging action through the seam will gradually enlarge it until an appreciable quantity of acid reaches the cement grouting of the inner lining. When this occurs the acid will attack the grout. If the steel shell is not tight, and the acid reaches a point on the shell where it can work through to the atmosphere, the action can become extremely rapid. For instance, if over a period of time the acid has gradually cut through the grout and reached a small opening at a loose rivet where it has access to the atmosphere, it may happen that the entire rivet will be cut away in the period of one cook.

Defects in the lining are usually detected by inspection between cooks. If an appreciable quantity of acid penetrates the lining while the digester is under pressure during a cook the acid tends to run back out of the lining when the pressure is relieved and shows as a wet spot on the lining surface. The location of the spot is carefully noted and inspected on the first opportunity. In some cases it is necessary to replace one or more brick, but in any case the work required to seal the lining surface is done as quickly as possible.

Even with the best possible installation the lining will require constant attention during all its period of service. The movement of the acid and chips in the digester tends to wear away the litharge and glycerine mortar between the bricks. This condition must be corrected by pointing up the

worn sections with fresh mortar. If this is not done and the wearing is permitted to extend over a period of time it causes scaling or spalling, the face of the brick being cracked away by penetration of heat through the exposed ends. The operating life of the lining is very seriously reduced if this takes place. Under normal conditions, with proper inspection and maintenance, a lining will last from five to ten years, depending upon the type of acid used, the length of the cooking period, and other similar factors.

Auxiliary Fittings

Certain auxiliary equipment is used on practically all digesters, including an inlet line for the acid, a bottom tee and blow valve, top and side relief strainers, sampling cocks, thermometers, pressure plugs, and top cover. The bottom tee is bolted to the bottom sleeve. The bottom tee serves to seal the bottom cone of the digester and also provides a point of attachment for other fittings such as the blow valve and steam-and-acid line. The type of auxiliary fittings attached is subject to some variation, though all digesters are equipped with a blow valve fitted to the bottom tee. The blow valve discharges into the blow pipe which directs the contents of the digester into the blow pit at the finish of the cook. All of the Camas digesters are also fitted with a combination steam-acid inlet line at the bottom tee. A check valve is located between the bottom tee and the steam-acid line to prevent chips or pulp being forced back into the line during periods if, for any reason, the pressure in the digester exceeds the steam or acid pressure in the line.

Fittings such as thermometer wells and pressure plugs are made up as separate castings. In each case the casting has a shoulder on the inside which draws up tightly against the sleeve in the lining and shell. The thermometer well or pressure plug is held in place by lock nuts on the outside of the shell. The thermometer wells usually extend from four to eight inches into the digester beyond the surface of the lining. The wells are drilled to within an inch or so of the inside end, the bulb of the recording thermometer inserted into the thermometer well and held in place by a lock nut on the outside of the shell.

The pressure plugs are drilled their full length so the cooking acid enters the plug. The acid resistant tube extending from the pressure plug to the pressure recorder is filled with oil which is trapped to prevent the oil draining back into the digester. By this means the pressure within the digester is directly transferred to the recording instrument but the instrument is protected from contact with the cooking liquid. Fittings for drawing samples of the liquor from the digester are attached in the same way as noted above. An acid-resisting valve, often a plug cock, is attached to this fitting so samples can be withdrawn at will.

The side relief fitting is located a few feet down from the top of the digester. The relative position on the shell is subject to some variation according to the operating practice of the plant where the digester is located. The fitting is attached to the shell in the customary way. A special strainer, however, is attached to the sleeve inside the digester and the sleeve discharges through a control valve to acid-resisting piping which joins the main relief system of the digester.

An acid-resisting bronze or stainless steel sleeve is installed in the top of the digester to serve as a seal between the lining and the shell. A bronze or stainless steel cover fits in place against the top sleeve, being held in position by heavy nuts and shackles. A top relief strainer is attached to the cover. The discharge from the strainer passes through a sleeve, thence to a top relief valve. Acid-resisting piping connects the discharge of the top relief valve with the relief recovery system. A special flange coupling is located on this top relief line near the cover. When the digester is to be filled with chips this coupling is disconnected, the bolts and shackles then released on the cover and the entire cover assembly swung free of the top of the digester by means of a special swing lift.

The steam line extends from the main steam header above the digester to the bottom tee. The acid supply line to the digester joins the steam line at an elevation slightly above that of the top cover of the digester. This acid-steam line arrangement is known as the Dooley system. The acid line from the storage tanks to the juncture of the steam line is made up of extra heavy lead tubing. An acid-resisting bronze or stainless steel valve is placed on the acid line at the tee where it joins the steam line and an acid-resisting valve is also located in the steam line above the point of union with the acid line. The section of steam piping between the steam header and the acid-resisting steam control valve is formed of the steel piping ordinarily used in steam installations. However, the piping below this valve is made of extra heavy copper or stainless steel to resist the action of the acid. This section of the pipe is in contact with the acid during the period of the cook, thus making it necessary to use an acid-resisting material. Another arrangement consists of separate steam and acid lines connected to the bottom tee.

Digester Valves

The valves used on a digester are probably the most important part of the operating equipment, since control of the cooking action depends upon good valves. For this reason all mills give a great deal of attention to their proper design and maintenance. The usual digester installation, shown in Fig. 58 includes the following valves:

Blow valve, steam valves, acid valve, side relief valve, top valve, top by-pass valve, and top relief back valve. Each of these is in contact with the acid during a cook. Leakage through these valves has a very detrimental effect and in some cases can allow so much of the cooking liquor to escape that the pulping action in the digester stops and the product is of a very inferior quality. The valves are usually made with replaceable seats and discs. They can be Y, angle or globe type. In any case, the design must provide for an ample packing gland on the stem. Under certain conditions fiber discs are very satisfactory. No matter what type of valve is used, proper attention must be given to its maintenance, otherwise the corrosive action of the cooking liquor or the deposits which tend to accumulate within the valve will nullify the best in design and material.

Acid Resisting Metals

During the last few years much progress has been made in the production of stainless steels for tubing and castings suitable for service in sulphite mills. These materials are now rapidly replacing the copper and bronze fittings previously used. Most of the stainless steels include about 18% nickel and 8% chromium and have a low carbon content. Some of the most successful stainless steels also include a small amount of molybdenum. It has been found that the amount of carbon has a very pronounced effect upon the acid resistance of the stainless steel. This is evidently because the carbon is not dissolved in the metal but occurs as an impurity between the grains. By the use of molybdenum the carbon is stabilized in the form of a carbide and the acid resisting properties of the alloy are greatly increased.

A factor in the production of stainless steels of equal importance to the composition of the alloys used is the heat treatment which must be given to the metal after it has been poured into the form of castings in the foundry. With proper heat treatment all stainless steels show a marked increase in resistance to the action of acid. This heat treatment consists of maintaining the castings at an elevated temperature for a definite period. At high temperatures the carbon is absorbed into the metal and the grain size is reduced. While the grain structure is in this condition, due to the high temperature, the casting is plunged into a water bath which reduces the temperature so rapidly that the grain structure of the metal does not change appreciably during cooling. If the stainless steel castings were permitted to cool slowly the crystals would grow in size during cooling and a considerable proportion of the carbon would re-deposit between the faces of the crystals. The proper heat treatment is therefore very essential to the acid resisting properties of stainless steel.

Digester Capacity

After the digester has been filled with chips and acid these must be heated to a temperature of approximately 280° F. since the cooking action is very slow at lower temperatures. One of the early successful methods of cooking abandoned attempts to heat the acid and chips in the digester with submerged copper steam coils and simply introduced the steam required through the bottom tee of the digester. This method has been followed for many years. In heating the digester contents to this top temperature by the introduction of steam through the bottom fitting a large quantity of condensate is formed within the digester. The steam enters the digester as gas but after giving up its heat again becomes liquid occupying a definite part of the digester volume.

To appreciate the problems of the digesting process, some consideration must be given to the way the volume of the digester is taken up by chips and acid. When a digester has been filled to capacity with chips there still remains a large volume of unoccupied space between and within the chips. The following approximation illustrates the condition when Western hemlock is used.

When all of the chips possible have been run into the digester from the chip bins, the digester will contain approximately 17,800 pounds of chips per thousand cubic feet of digester capacity. Assuming that the chips normally contain 50% moisture, then each thousand cubic feet of digester capacity contains 8,900 pounds of chips, bone dry basis, and 8,900 pounds of water.

Since the chips are made up of fibers which are shaped somewhat like a hollow tube, a considerable amount of space exists within and between the fibers in the chips. The actual space taken up by the solid material of the chips is only about 78 cubic feet, and the actual digester volume taken up by the chips about 318 cubic feet. The difference between the 318 cubic feet occupied by the chips and 78 cubic feet of solid material in the chips is 220 cubic feet, this being the amount of space contained **within** the chips. The water which exists as moisture in the chips will occupy 142 cubic feet so there actually exists 98 cubic feet of available space **within** the chips as these are run into the digester from the chip bin.

It has been noted the chips occupy only 318 cubic feet for each thousand cubic feet of digester capacity, therefore 682 cubic feet exists as space unoccupied by the chips. The **total** available space remaining in the digester after the chips have been run in is approximately 780 cubic feet per thousand cubic feet of digester capacity. If all of the space **between and within** the chips is occupied by acid when the digester is pumped, a total of 5,850 gallons can be pumped in per thousand cubic feet of

digester capacity. This is equivalent to 2,650 gallons per ton of pulp produced.

Allowance for the volume of condensate must be made when the digester is pumped with acid. It is the usual practice to pump the digester so that it is not completely filled with acid. This provides a space within the digester for the condensate which forms as the digester is heated with direct steam through the bottom tee. After a period the volume of condensate will fill all of the available space remaining in the digester. When this condition occurs, no additional steam will flow into the digester. In order to increase the temperature of the chips and acid within the digester after this condition occurs, it is necessary to relieve a volume of liquor from the digester at least equal to the volume of condensate formed from the steam needed to heat the contents of the digester to the required cooking temperature.

If a relatively large volume of acid is pumped into the digester, only a small quantity of steam can be admitted before the volume of condensate completely fills the digester, making it necessary to relieve liquor before additional steam can be admitted. However, if a small quantity of acid is pumped into the digester, a large volume remains available for the condensate with the result that the temperature in the digester can be raised to a relatively high point before the volume of condensate becomes great enough to occupy all of the space within a digester. It is thus evident that the volume of acid pumped into the digester has a marked effect on the temperature that can be obtained in the mass of chips and acid before it is necessary to relieve liquor from the digester to permit entrance of additional steam.

Steaming

The introduction of steam through the bottom tee of the digester serves a very important purpose besides that of the introduction of heat. The velocity of the steam is relied upon to set up motion in the contents of the digester. It has been found that the flow of steam into the bottom tee causes an upward motion along the axis of the digester. The acid travels upward along this center line and downward along the shell. The rate of this motion increases during the steaming period. By observation it has been noted that from $2\frac{1}{2}$ to 4 hours are required to turn the acid in the digester when the cook is first started. The rate of motion increases so that each successive turn requires approximately half the time of the one preceding it. By the time the digester has reached the top cooking temperature the liquid contents of the digester have completed this cycle from four to six times.

It has been found that a definite relationship must be maintained between the rate of flow of steam into the bottom fitting and the motion of the liquor in a digester. If the velocity of the steam entering the bottom tee is too great it tends to slip through the liquor and under certain conditions will bore to the top through the entire mass of chips and liquor. Careful attention is therefore given to the rate of steam flow in the very early stages of the cook and the flow rates are held so low that the steam has ample time to condense before it travels into the main body of the chips. As the motion of the liquor in the digester increases, the flow rate of the steam can also be increased. If the cook has been properly started, very large quantities of steam can be introduced, resulting in a good circulation and without any danger of boring. Much of the success and economy of the cooking operation depends on close attention being given to the steaming rate.

Relief

The liquor relieved from the digester is conveyed through stainless steel tubing to a relief header. All of the digesters discharge into this com-

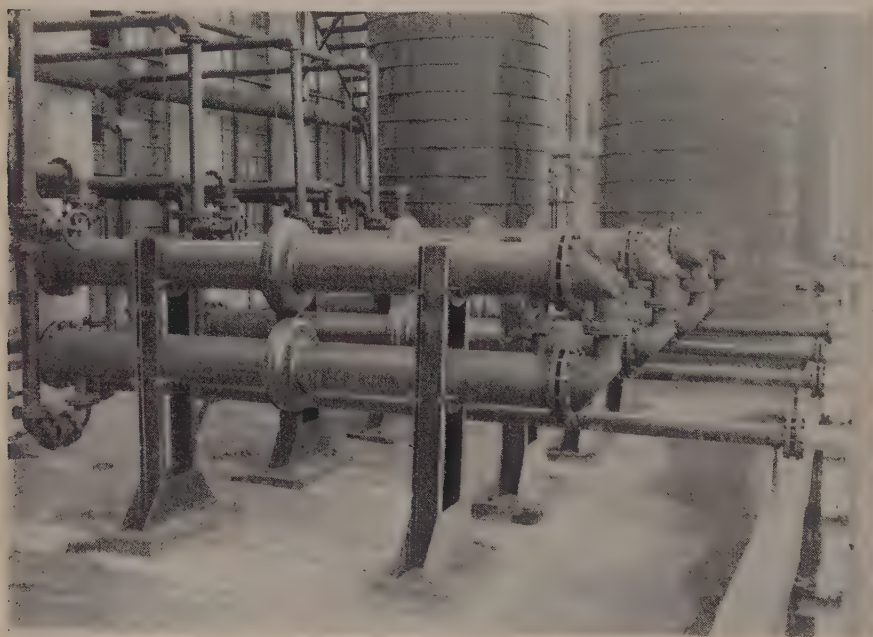


Fig. 60 Relief Coolers

mon header which in this way acts as a mixing chamber. The relief next passes through coolers, the most recent design of which is made with

stainless steel tubes rolled into tube sheets. The tube nest thus formed is jacketed with an iron casing. Cooling water flows through the jacket around the tubes while the relief liquor flows through the tubes. After cooling, the relief liquor is reclaimed in a recovery tank or tower.

The original discovery on which the sulphite process is based—that a water solution of sulphur dioxide has the property of dissolving most of the non-cellulose constituents of wood, was quickly supplemented through commercial development of the process with the knowledge that the solution used must also contain a basic material such as magnesium, sodium, or calcium. Factors of economy have mainly limited the base material used to calcium.

The cooking acid is a relatively weak solution of chemical compounds containing sulphur and lime. These substances exist in the solution as sulphurous acid and calcium bisulphite. The sulphurous acid readily forms when sulphur dioxide is dissolved in water. It has previously been noted that the solid material in the wood occupies only a small part of the space of the digester. The acid in which the required cooking chemicals are carried in solution serves as a medium for distributing these chemicals through the mass of chips as well as into the fibers of the chips.

One important characteristic of the acid is dependent on the fact that a large quantity of sulphur dioxide is simply in solution in the water. The amount of sulphur dioxide which will exist in a water solution depends upon the temperature of the solution and the pressure in the vessel containing the solution. The acid is pumped from the storage tanks to the digester at a temperature which produces only a small gas pressure. However, as the steam raises the temperature of the acid in the digester there is a rapid build-up in gas pressure in the vessel. This pressure builds up more rapidly with a strong acid so the actual rate at which the pressure increases with temperature depends upon the character of the acid used.

Upon continued heating, the gas pressure within the vessel will quickly increase to a point in excess of the safe working limit of the steel shell of the digester. This fact makes it necessary to limit the cooking pressure, this usually being set between 65 pounds and 90 pounds per square inch. When the pressure in the digester reaches this point it becomes necessary to relieve a sufficient quantity of sulphur dioxide from the solution to hold the pressure in the digester at the pre-determined pressure. Increasing temperature, as noted, generally results in increased pressure. The pressure is held at the predetermined pressure by weakening the acid through relief of SO_2 from the digester while the temperature is being increased.

We thus find that liquor must be relieved from the digester to provide a space for condensate from the steam, and gas must be relieved from the digester to reduce the pressure within safe working limits.

Liquor Penetration

It has been found by experience that particular attention must be given the first hours of the cooking cycle. This results from the manner in which the chips are cooked. The cooking process does not separate the fibers one by one as a mason removes brick in dismantling a brick wall.

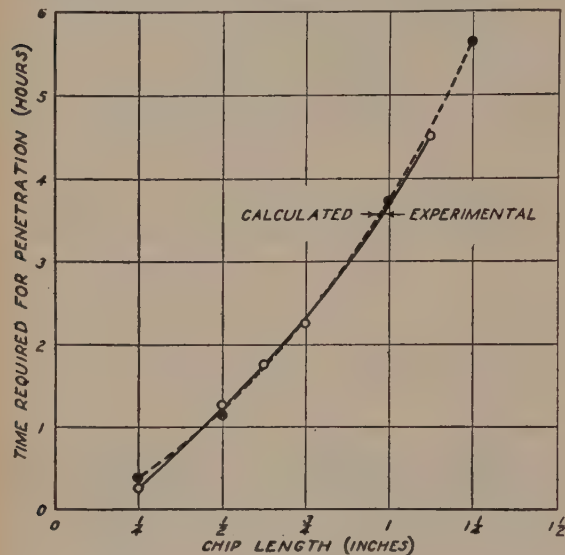


Fig. 61
Penetration Time for
Western Hemlock
Chips

The cooking action does not proceed entirely from the outside surface of the chips toward the center. Instead, the chips must be thoroughly saturated with acid before any appreciable cooking action takes place. When this penetration has been completed, a large part of the chemicals required for digestion have been absorbed by the chips. In case a cooking temperature is reached before the chips are thoroughly penetrated with the acid, little further penetration will take place. As a result, the outside penetrated surface of the chip will be defibered by the cooking action but the unpenetrated center will remain practically untouched during the entire cooking process.

These factors of chip penetration and pressure generation within the digester have a direct effect upon the amount of acid and the cooking methods used. Generally, the gas pressure in the digester will reach 75 pounds per square inch when the acid in the top section of the digester has attained a temperature of approximately 210° F. Therefore, it becomes necessary to start relieving from the digester at about this temperature. The volume of acid pumped into the digester is usually adjusted so that the condensate formed in bringing the cook to a temperature of 210° F.

approximately fills the vessel. When this is done, the relief is mainly liquid, the gas being carried from the digester in solution. If, however, a smaller volume of acid is used and the digester reaches a pressure of 75 pounds

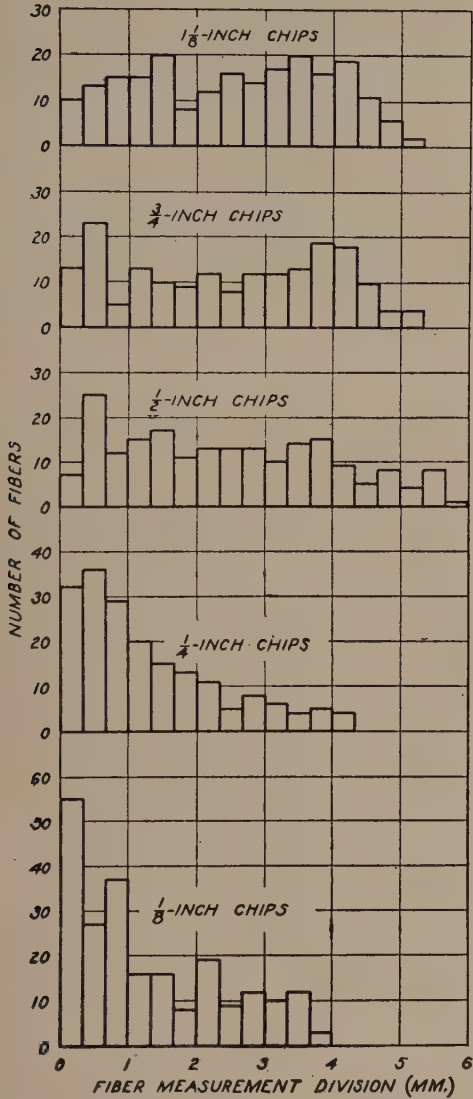


Fig. 62
Fiber Distribution in Pulps
from Western Hemlock Chips

per square inch before the condensate has filled the vessel, the relief is mainly gas. It is very difficult under this condition to prevent the strength of the cooking acid from being rapidly depleted through excessive relief of sulphur dioxide. The steaming rate and volume of acid used are adjusted so

the digester reaches 75 pound pressure in $2\frac{1}{2}$ to 4 hours, the period which has been found necessary for complete penetration of the chips. During this period the strength of the acid is not reduced by any relief from the digester. When penetration has been completed, a large part of the chemicals required have been absorbed by the chips so that further weakening of the acid by relief from the digester does not so seriously affect the cooking action.

Fig. 61 shows the rapid increase in time required for complete penetration of Western hemlock chips as chip length increases. These results are derived from tests made at the U. S. Forest Products Laboratory. In these tests some interesting results were obtained on fiber length in various chip sizes. This is illustrated in Fig. 62 and shows that chip lengths below one-half inch produce a relatively high proportion of short fibers.

Chemical Usage

Experience has made it evident that an excess of cooking chemicals is always required in the digester in the production of pulp of uniformly high quality. Since the excess chemicals are expensive, methods of recovery were developed early in the history of the process. It is not only advisable to recover the chemicals for economic reasons but also because the discharge of excessive quantities into the blow pit at the completion of the cook creates a nuisance through the release of large quantities of sulphur dioxide to the atmosphere from the blow pit. The excess chemicals are recovered from the digester as gas or in solution in the liquor relieved during the steaming period. A certain proportion of the chemicals cannot be recovered from the digester. The largest proportion of these is consumed in the chemical reaction which renders the non-cellulose parts of the wood soluble.

The amount of sulphur theoretically required for the cooking action is variously estimated between 175 and 200 pounds per ton of pulp. Since the actual sulphur usage exceeds this amount by as much as 75 pounds to 150 pounds, it is evident that considerable loss also occurs. Most of this is carried from the digester into the blow pit at the completion of the cook. Though a large quantity of liquor is recovered from the digester as relief during the cook, most of the liquor must be left in the digester in order to make the pulp fluid enough to flow through the blow pipe and into the blow pit when the cook is completed. The chemicals remaining in the liquor are thus lost.

The chemicals required for digestion of the wood or lost to the blow pit must be made up, this being the function of the acid plant. It should be noted that the amount of chemicals required depends upon the cooking processes in the digester, and that the acid plant only supplies this requirement.

In a somewhat similar manner, the volume of acid produced in the acid plant is also to be determined by the digestion process. We find that water enters the digester as acid, as condensate from the steam, and as moisture in the chips. All of this volume is recovered through the relief system except that lost to the blow pit at the end of the cook. The volume of moisture in the chips, condensate from the steam, and the fresh water used in production of raw acid in the acid plant cannot exceed the volume of liquor lost to the blow pit. Of course the moisture content of the chips cannot be controlled, and the steam requirement is quite definite for each cook, so the volume of water from these two sources is not subject to manipulation by the operators. For these reasons, the amount of water used in the acid plant must be controlled to supply the quantity required. We thus find that the quantity of chemicals and the volume of water used in the acid plant are very closely defined by the cooking process.

Indirect Heating and Circulation

During the development of sulphite cooking, and for many years following, operators had recognized the desirability of holding higher concentrations of acid in the digester during the cooking period so as to avoid the considerable dilution which occurs by use of the direct steaming method. To that end steam coils were used inside the digester, but this never proved entirely satisfactory due to the fact that sufficient coil area could not be provided to cook the digester in less than 18 to 22 hours. There was also the disadvantage of a large amount of repair work to these heating coils, which were constructed of lead due to the necessity of acid-resistant material.

Even more important was the desirability of obtaining temperature equalization throughout the digester, during the whole cooking period, which is never possible by the use of direct steaming. Morterud patented the first indirect heating and circulating system for both kraft and sulphite digesters about 1908. This system was immediately successful on kraft pulping and is generally used on stationary digesters today.

However, the acid-resisting metals available at that time—copper, lead and bronze—were not suitable, and no system installed, of which there were several, proved satisfactory until stainless steel became available. The systems today are substantially the same as the original Morterud patent.

As the indirect heating and circulating systems in use now are designed so that a complete turnover of the liquor within the digester is made in 15 minutes or less, it can readily be seen that temperature equalization

throughout the digesters is achieved to the greatest possible extent. This makes it possible to produce a more uniform pulp of superior quality than with the direct steaming system.

Some plants using the hot acid system (later described) have installed the circulating system without the heater and find considerable improvement in pulp quality.

During the past eight or ten years a great many direct cooking systems have been replaced by indirect heating and circulating systems due to the economy and quality improvement attained by operation of these systems. A number of installations of this type have been made since 1930. Nine of the ten digesters in Camas have been so equipped during this period.

Two of the Camas digesters are 19 x 58 feet in size and with a capacity of more than 25 tons each per cook.

The stainless metal used on Camas digester fittings is a chromium-nickel-molybdenum alloy known as ESCO Alloy 45. Piping made of this metal is all cast.

Fig. 59 shows the main features of the Camas circulating system. It will be noted that these include a strainer section near the top girth strap of the shell, a pump, and a heat exchanger unit. The acid is withdrawn from the digester by the suction of the pump, then forced through the heat exchanger and into the bottom tee. The heat exchanger includes a tube nest made with stainless steel tubes rolled into tube sheets. Tube nests used at Camas are known as the two-pass type, in which the acid enters a header which equally divides the tubes across the bottom tube sheet. The entering acid is forced upward through one group of tubes, flows across the top tube sheet within a dome-like cover and downward through a second group of tubes to the other section of the bottom header. From this point it travels to the bottom of the digester through a cast stainless steel pipe. The tube nest is contained in a steel jacket, which also forms the steam chamber of the heat exchanger. The steam enters the top of this chamber and the condensate collects above the bottom tube sheet.

The condensate is automatically released from the heater and collected in a storage tank, from which it is pumped to the hot-well at the steam plant. The pump used to circulate the acid normally has sufficient capacity to turn all of the acid in the digester every 12 to 15 minutes. The heat exchanger unit usually has sufficient heating surface to permit the temperature of the chips and acid in the digester to be raised about 40° F. per hour.

Use of this equipment has a very definite effect upon the quantity of acid pumped into the digester or required as make-up in the acid plant.

Since no condensate forms within the digester, it is not necessary to allow for this, and the digester can be pumped full of acid. It has been found that this is an advantage because the chips gradually absorb the acid, and the level in the digester drops. Occasionally the level will drop so low the circulating pump will lose its suction at the strainers and when this occurs no further circulation will take place. The amount of acid absorbed by the chips depends upon the density of the wood being cooked and its moisture content. Ordinarily the acid absorbed by the chips does not lower the level in the digester sufficiently to cause loss of circulation.

Another method has also been developed to avoid the heat loss which occurs when the relief from the digester is passed through the coolers. The relief must be cooled to a temperature which will permit the SO_2 to remain in solution without developing excessive pressure in the storage tanks. Use of storage tanks or accumulators built to stand operating pressures up to 60 pounds per square inch makes it possible to store the hot relief liquor just as recovered from the digester. This is known as the hot acid system.

The equipment required for the hot acid system includes two accumulators, one operated under pressure of about 40 pounds and the other under pressure of about 20 pounds per square inch. The relief from digesters under full operating pressure is directed to the high pressure accumulator, the digester pressure being sufficiently in excess to deliver the relief against the pressure in the accumulator. At the end of the cook, however, when the pressure in the digester is being reduced through recovery of large quantities of sulphur dioxide, the digester pressure is no longer sufficient to force the relief into the high pressure accumulator. The relief is then directed into the low pressure accumulator. Raw or make-up acid is pumped to the low pressure accumulator from the storage tanks, thence to the high pressure accumulator from which the cooking acid is pumped to the digester.

The equipment on the high pressure accumulator usually includes a pump for circulating liquor from the accumulator to the digester and back. The cooking liquor is circulated for a period of from one to two hours after the digester has been filled with acid and before any steam is admitted. In this way the temperatures of the acid and chips in the digester are equalized at about 180°F . The steam required to raise the temperature in the digester to the top cooking temperature of approximately 280°F . is admitted through the bottom tee.

One advantage of this system is the fact that higher lime concentrations are maintained in the cooking acid during the period of chip penetration. This evidently has a favorable effect on the color of the pulp produced by this method.

It has been noted that a number of different methods can be followed in applying heat to the contents of the digester. This choice of methods is characteristic of the sulphite process today. The digesters used are about the only equipment following a generally adopted design. Other equipment, such as relief coolers, recovery tanks, storage tanks, etc., are selected according to the processing methods adopted for each plant. There are certain principles of the process, however, which are basic for all plants. Heat is always applied by steam. The cooking rate is controlled by controlling the flow of steam to the digester. The relief liquor and gases are recovered to as great an extent as possible. A large quantity of sulphur dioxide is recovered at the end of the cook by relieving the gas to the recovery system. Sufficient pressure is left in the digester, however, to blow the pulp and remaining liquor into the blow pit. The chemicals required are supplied in a solution made by mixing the relief recovered from previous cooks with raw acid produced in the acid plant.

Sulphur Burners

Sulphur dioxide is produced from sulphur by burning it in air in equipment which permits control of the rate of combustion. The sulphur required for the production of sulphur dioxide can be obtained from a number of sources. In the early days of the industry sulphur was most usually obtained by roasting a sulphur iron ore known as pyrites, the sulphur being driven off as a gas by this method. For a number of years, however, the sulphite industry in this country has been supplied from the enormous natural deposits of pure sulphur in Louisiana. The sulphur supplied to Camas is obtained from this source and in such a pure state that it is the most reliable raw material used in the process.

When started, combustion is continuous so long as a supply of sulphur and oxygen is available. The combustion, however, does not take place rapidly. It is also retarded by impurities which form a coating over the melted sulphur and tend to smother the flame. By experience it has been found that liquid sulphur can be burned continuously in a rotating cylinder. The sulphur is fed through a control valve to a rotating cylinder or burner, the ends of which are sharply tapered. The cylinder is rotated by the driven trunnions on which it rests. The forward tapered end is closed by a swing door equipped with dampers. The sulphur feed line passes through the front door along the axis of the cylinder so that its relative position is not altered by rotation of the burner. The opposite tapered end of the burner is immediately adjacent to the inlet of the combustion chamber. The iron cylindrical shells of the Camas burners are 36 inches in diameter, the cylinder sections 96 inches in length, and the tapered ends are each 27 inches, giving an overall length for each burner of 150 inches, or $12\frac{1}{2}$

feet. The openings at each end of the burner are approximately 14 inches. Larger sized burners are used by some mills. A sketch of the sulphur burners is inserted in Fig. 63.

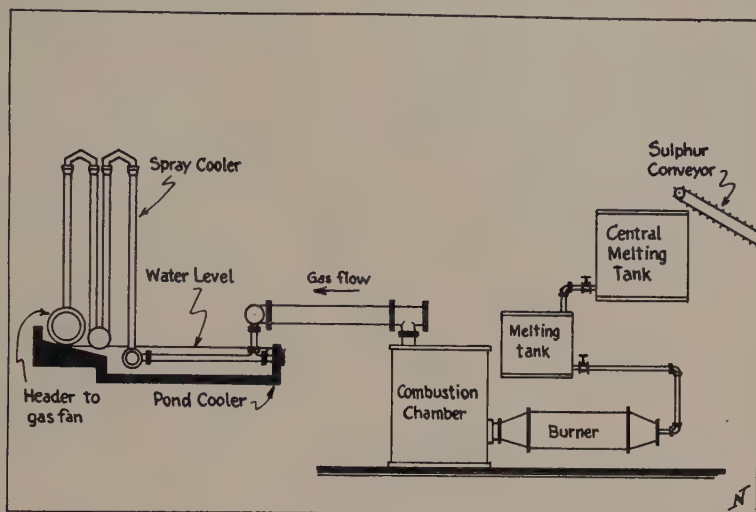


Fig. 63 Sulphur Burner

The sulphur is first melted in a steel tank equipped with steam coils. Careful attention is given to maintaining the sulphur at a temperature of approximately 260°F . by regulating the pressure on the steam coils. At temperatures much above this, the sulphur has the peculiar property of becoming less mobile and pours no more easily than heavy molasses. When maintained at the temperature noted the liquefied sulphur flows readily through valves and supply pipe, these generally being steam jacketed to maintain the sulphur at the proper temperature. It is the general practice to operate the burner in such a way that a pool of liquid sulphur is formed in the burner ends. This pool is normally from three to four inches deep and the supply of sulphur is regulated to hold this approximate volume at all times.

The rotation of the burner causes a volume of sulphur to adhere to its interior surface, thus exposing a relatively large area of liquid sulphur to the atmosphere in addition to the surface of the pool. Small amounts of organic material and impurities in the sulphur gradually accumulate in the burner, floating on the surface of the liquid sulphur to such an extent as to smother combustion. For this reason the major portion of the sulphur burns from the surface of the burner. The rate of rotation is so adjusted that only that amount of sulphur is picked up which will adhere firmly to the surface of the burner. Any excess above this amount tends to drip, the

droplets being carried into the combustion chamber as liquid sulphur. The speed of the burner is also adjusted so that the film of sulphur is not completely burned. By maintaining this film of sulphur on the surface, the metal of the burner is protected from direct contact with the flames.

Another action takes place in the burner besides the combustion of sulphur. This results from the fact that the large amount of heat liberated in the burner increases the temperature of the liquid sulphur to an extent that causes part of the sulphur to vaporize, changing it into a gaseous state in the same way that water is changed into a gas or vapor by application of heat. The air needed for the combustion of the sulphur is admitted through dampers at the front end of the burner. Since the movement of air through the burner also carries with it a quantity of sulphur vapor, it is necessary to pass these products through a second chamber where additional air can be admitted to complete combustion of all of the sulphur vapor carried from the burner. This second unit is known as the combustion chamber and is built to withstand temperatures up to 2800°F . A damper of some type is placed at the junction of the burner and combustion chamber, providing a means of controlling the air supply at this point.

The combustion chamber is usually a vertical cylinder about 8 feet in diameter and 12 feet in height or larger. This chamber is lined with fire-resistant brick and is usually baffled in such a way that the gas follows a very irregular path in passing through it.

The heat of combustion in the burner and combustion chamber is partly dissipated by radiation from the outside surfaces of these units. A large part of the heat, however, is absorbed in elevating the temperature of the gases. Since sulphur dioxide at high temperatures will not readily dissolve in water it is necessary to pass the gases from the combustion chamber through a cooler where the temperature is reduced as nearly as possible to atmospheric temperature, the heat so liberated being carried off in the cooling water.

A small amount of sulphuric acid is formed during the combustion of the sulphur. Liquid sulphuric acid is very corrosive to iron and steel, but at temperatures above its boiling point of (640°F .) this compound exists as a gas and has very little effect upon iron. For this reason it is possible to use cast iron piping between the combustion chambers and the lead coolers, as the temperatures of the gases in the iron pipes is above this point. Below this temperature the sulphuric acid returns to a liquid state, requiring the use of coolers constructed of lead pipe.

Under normal operation the gases leave the combustion chambers at temperatures from 1800° to 2500°F . and enter the lead coolers at about 1000° to 1400°F . Since the melting point of lead is about 620°F ., the

gases actually enter the coolers at temperatures above the melting point of lead. This makes it necessary to have the first lead sections of the cooler submerged in a pond of water. The length of the lead tubes in the submerged section of the cooler is normally 12 feet. The temperature of the gases is reduced below the melting point of lead in passage through this section of the cooler. The following section of the coolers can therefore be made up of vertical lead tubes in the form of an inverted "U". This type of cooler needs only to be sprayed with water to maintain a water film on the outside surface of the tubes at all times. A large part of the heat is carried from the cooler by evaporation of water from the surface of the tubes. For this reason, the volume of cooling water required is less than for the submerged type of cooler.

Jenssen Towers

The cooled gases pass through a lead duct to the limerock towers. The draft on the burner and combustion chamber results from the operation of a cast lead fan located in this duct. This fan also forces the gas into the towers. These towers vary in size at the different mills but most of them are 90 feet high and up to 12 feet inside diameter, depending on capacities required. The towers are always built in pairs, at least, and some installations may have three or four. The method of operation requires at least two. Fig. 64. shows the design of a two-tower system. Each of the two

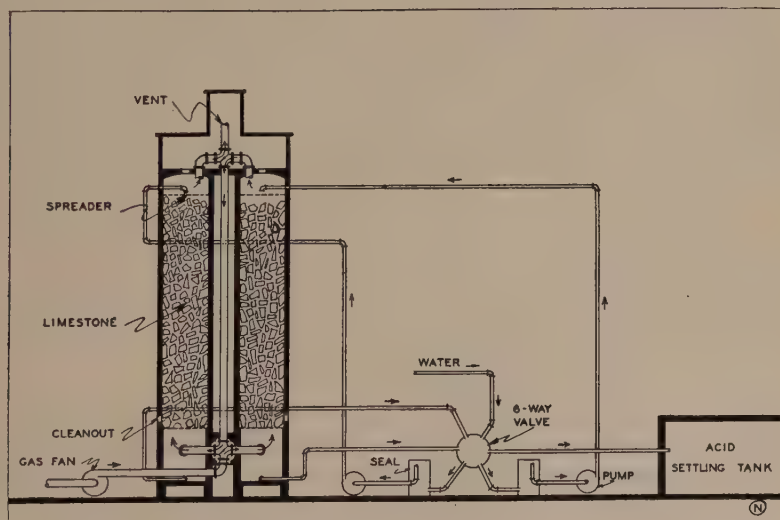


Fig. 64. Diagrammatic Elevation of Jenssen Towers

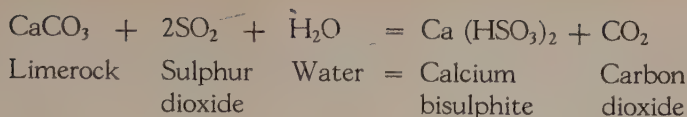
towers has a settling pond at the bottom, an absorption space between the surface of the settling pond and heavy wood cross-beams supporting

the gridiron on which the limerock rests, a large volume of limerock, and a distribution or spreader board near the top of the tower. Other equipment includes a four-way gas cock at the bottom and a three-way gas cock at the top, and an inlet line in the bottom and top of each tower.

The gases from the burner pass into the absorption chamber of the tower through the four-way gas cock and inlet line as shown in the sketch. The gases then move up through the limerock, leaving the tower at the top outlet and thence passing to the top three-way gas cock where they are directed through a by-pass line to the inlet at the bottom of the second tower. The gases pass up through this second tower, the waste gases finally leaving through the vent pipe at the top, being discharged to the atmosphere with the help of a steam exhaustor or fan if necessary.

The water used in the production of acid is pumped to the spreader board at the top of the No. 2 tower. By this means, the water is distributed over the exposed limerock through a number of small perforations, slowly trickling downward over the surface of the limerock in the tower. Finally dripping from the limerock, it falls through the absorption area of the tower and is collected in the pond at the bottom. An overflow line from this pond carries the weak acid to a pump which forces it to the top spreader board of No. 1 tower. Here, it follows a similar route as previously, over the surface of the limerock, finally collecting at the bottom of the No. 1 tower. It will be noted from the sketch that the fresh water enters the tower from which the waste gases are discharged to the atmosphere and that the relatively strong gas from the coolers enters the tower from which the acid is discharged. This produces a counter-current flow of water and gases and results in the fresh water being used to absorb the traces of SO_2 left in the waste gases just before these are discharged to the atmosphere, and in the strongest gas being brought in contact with the acid as it leaves the towers. During passage of the water and gas through the towers, SO_2 is absorbed, a large proportion being absorbed in the section shown as the absorption chamber of the No. 1 tower. As the SO_2 is absorbed from the gases, these become continuously weaker in this material. Nevertheless, absorption continues to take place by reason of the counter-current flow in the towers.

After sulphur dioxide has been dissolved in water, the solution is known as sulphurous acid. The acid thus formed has the property of dissolving limerock, liberating carbon dioxide as a gas from the calcium carbonate of which the rock is mainly composed. The carbon dioxide is vented to the atmosphere from the limerock towers along with other waste gases. In dissolving the limerock, part of the sulphurous acid reacts with the calcium of the rock to form calcium bisulphite as shown by the following chemical equation:



Thus, we find that the limerock towers serve as an absorption chamber for dissolving sulphur dioxide in water, provide means for separating the sulphur dioxide from the waste gases and venting these to the atmosphere, and also provide a method for adding lime to the acid, this being very necessary in the preparation of cooking acid.

After overflowing from the pond of No. 1 tower, the acid flows through a tile-lined concrete chamber that serves as a settling pond where heavy suspended material settles out. The acid is now ready for final reenforcement by gas and liquor relieved from the digesters.

Production of the raw acid consumes between 350 and 400 pounds of limerock per ton of pulp produced. This means that many thousands of pounds of limerock are used in the towers each day. Since the production of raw acid is a continuous process, some method had to be devised for charging limerock into the towers while in service. This is done through the use of two limerock towers, by alternating them as No. 1 and 2 towers as in the previous description of these units. During the period that the strong gas from the coolers is being directed into one tower, the other can be charged with limerock. This is made possible by the action of the steam exhaust or fan on the vent line from the tower being charged with limerock. Sufficient suction is created to draw air into the tower through the limerock manhole, while the waste gases are being discharged from the tower through the regular vent. Usually the towers are alternated daily and the limerock is charged each day into the one serving as the weak, or No. 2, tower.

The combustion of sulphur in the presence of oxygen from the air unites these materials in the ratio of 1 to 1 by weight. One pound of sulphur unites with one pound of oxygen, the product being two pounds of sulphur dioxide. However, the **volume** of the oxygen is not altered by combination with sulphur in the formation of sulphur dioxide. One volume of oxygen from the air produces one volume of SO_2 as a gas. Air contains approximately 21% oxygen by volume, the balance being mainly nitrogen of no value in production of sulphite acid. Theoretically, it is possible to have all of the 21% oxygen in the air unite with sulphur to form a gaseous mixture containing 21% sulphur dioxide. In practice, only 80% to 90% of the oxygen in the air combines with sulphur, so that an excess of oxygen is carried from the combustion chamber at all times. This is purposely done to prevent carry-over of unburned sulphur vapor from the combustion

chamber to the coolers, where the vapors would be solidified and would seriously reduce the capacity of the coolers.

Strength of Acid

The temperature of the fresh water used in the limerock towers has a very marked effect upon the composition of the acid formed. Temperature differences of even a few degrees immediately affect the composition of the acid, and a temperature variation of about 25° F. between summer and winter conditions is responsible for a most persistent problem in the production of acid.

Where the gases from the coolers enter the absorption section of No. 1 tower they immediately come in contact with the partially formed acid dripping from the limerock. If the temperature of the water is relatively low, the sulphur dioxide is quickly absorbed and only a small amount of it carries any distance up through the limerock of the tower. When the temperature of the water is high, as during summer conditions, the sulphur dioxide is not readily absorbed, but is carried upward through a large volume of the rock while absorption is taking place. The sulphurous acid is then formed well up in the tower, and, as it trickles down over the limerock, has a much greater length of time for reaction with the calcium carbonate. The lime content of the acid tends to be considerably higher during periods when the warm water is being used, i.e., summer as compared to winter conditions.

Under normal operating procedures, the strength of the acid is adjusted to hold the lime content fairly uniform throughout the year, with the result that there is a wide fluctuation in the amount of dissolved or "free" SO_2 , this being relatively high in the winter time and low in the summer. In order to maintain a more uniform strength of sulphurous acid, a method of adding additional sulphur dioxide to the raw acid has been adopted. The equipment used consists of a suction pump for withdrawing the burner gases from the main gas supply line to the limerock towers. The gases withdrawn by the pump are discharged under pressure into a closed tower filled with some type of checker work which greatly increases the surface exposure within the tower. The raw acid is pumped from the settling tank to the top of this absorption tower where it is discharged over the checker work. As it travels downward in a thin film over a large expanse of surface it is brought into intimate contact with the gases being forced into the tower. In this way a considerable quantity of sulphur dioxide can be brought into solution and the strength of the raw acid increased. The waste gases and SO_2 not absorbed within the tower are returned to the main gas supply line where they then follow the regular circuit through the lime-rock towers.

Weekly or periodic shutdowns of the entire plant are necessary for inspection and maintenance. This shutdown is normally made on Sundays. When the acid plant is again to be started up, the procedure is as follows: Melted sulphur is introduced into the burners and ignited. After a quantity of sulphur has accumulated in the burner and the combustion is proceeding over the entire exposed surface of the sulphur pool, the burners are started rotating. It requires from three to six hours for the temperatures in the burner and combustion chamber to increase enough to obtain good combustion of the sulphur vapors carried into the combustion chamber. In order to avoid a carry-over of sulphur vapors to the coolers during this period, a large amount of excess oxygen is introduced through the back dampers, with the result that the strength of the gas in sulphur dioxide is relatively low. The rate at which the sulphur is burned and acid produced must be held considerably below the normal operating rate to avoid sublimation of the sulphur in the coolers. The acid plant is started ahead of the cooking operation in the digester building, this interval of time being adjusted so the acid plant is operating normally by the time the first relief is released from the digesters. In this way, the balance between the volume of relief and volume of acid made is held nearly constant.

On the start up, the digesters are filled with chips and acid and the cover bolted in place. All the valves on the digester are closed. The steam valve is then opened slowly as required in starting a cook. The successive cooks in other digesters are started at regular time intervals. The spacing between the cooks is adjusted according to the production required from the mill. Each cook is controlled so that the temperature and pressure within the digester follow predetermined curves. Under well controlled operating conditions, these curves are followed very closely, so the successive operations necessary in handling each cook follow a definite order and spacing. When this is done the operator can establish and follow a definite routine in handling a number of digesters. Each cook will then reach pressure in the same interval of time and the progress of the cook also follows a definite time sequence. The steam requirement, the volume of relief, the rate of relief and production of pulp become uniform, and this uniformity is reflected in the composition and quality of the cooking acid and finally in the character of the pulp produced. No single factor in the operation of the sulphite process is so important as scheduled uniformity in operating procedure. By this means, uniform composition of the acid is maintained and fluctuations in pulp quality are avoided.

Control of Cooking Operation

The strength of the acid in the digester can be varied over a wide range by manipulation of the relief valves during the cook. The best

method of handling the relief from each digester depends upon the number of digesters in service in the plant, the design and type of coolers and recovery system used, the temperature of the cooling water available and the type of pulp desired. The effect of cooler capacity, water temperature and other factors not under the immediate control of the operator tends to limit the character of the pulp produced in each digester. The operator is able to control the quality of the pulp only within the limits defined by equipment and physical plant factors.

Other characteristics of the cooking process make it difficult for the operator to achieve close control over the quality of the pulp produced. This is mainly because no satisfactory method has been devised for testing the pulp while the cooking action is in progress. After the digester has been filled with chips and acid, and the steaming cycle has been started, the effect of the progress of the cooking action is usually determined by testing samples of the liquor withdrawn from the digester. The progress of the cook shows itself in the liquor by the accumulation of material dissolved from the wood. The color of the liquor gradually changes from yellow to a deep wine red. This is the most evident change in the liquor during the cooking cycle. There is, however, also a concentration of the sugars removed from the wood and the generation of a sweet odor resulting from these. The concentration of the cooking chemicals in the acid is also gradually reduced as the cooking action progresses. Under normal conditions all of these changes take place gradually, there being no marked end point signifying completion of the cook.

A number of attempts have been made to withdraw samples of the pulp from the digester during the progress of the cook and in this way to exactly determine the progressive effect of the pulping action. However, it has been found almost impossible to withdraw small samples that are fully representative of the digester contents. Even under the most carefully controlled conditions, the pulp within the digester will show marked differences in quality from point to point and it has been found most satisfactory to rely upon tests made on the cooking liquor rather than upon small pulp samples withdrawn from the digester.

If the color and strength of the acid pumped into the digester varies from cook to cook, such variations are also reflected in the strength and color of the acid during the progress of successive cooks. If the pulping characteristics of the wood charged into successive digesters vary, these variations are also reflected in the strength of the cooking liquor, its color and the amount of sugars accumulated during the progress of the cook. It is therefore evident that the control over the cooking action, or the determination of completion, cannot exactly follow routine methods except under closely standardized operations.

Control over the progress of the cook is made even more difficult by the fact that the methods used for determining the strength of the acid pumped to the digesters do not reveal the actual cooking qualifications of the acid. Even though the analytical tests are accurately made, and the composition of the acid thus determined according to these tests, it will be found that the pulping quality of the acid can vary over a wide range even though the composition is reported as identical. This is due to the effect of the relief recovered from the digesters and mixed with the raw acid to form the cooking acid. The relief liquor from the digesters carries part of the material dissolved from the wood, the amount being greater in the relief taken from the digester during last stages of the cooking action. If a large quantity of relief liquor is withdrawn from the digester in the early stages of the cook, the color of the acid formed after mixing with the raw acid from the acid plant is a bright lemon yellow. If, however, the relief liquor used is taken during the last stages of the cook, the resulting acid becomes red. It will be found that the cooking action of these two types of acids varies and, further, that the pulp produced with each has particular qualities. In other words, the quality of the pulp produced depends upon the character of the cooking acid used and it has previously been noted that this in turn reflects the composition and quantity of the relief liquor and the type and degree of control obtained in the cooking process.

Many variations of technique have been applied in the sulphite process, each with definite equipment requirements; but the fundamental principles are always the same. In every case, a definite scheduled operating routine under close control and based on the characteristics of each plant are necessary for a uniform grade of pulp. This is one fundamental operating factor which applies to all plants irrespective of equipment or process variations used.

CHAPTER IX

BLEACHING

By F. E. WILLIAMS

Development of Bleaching at Camas

Pulp bleaching at Camas was first started in June, 1925, with a Fletcher type vertical bleaching unit, purchased from the Pulp Bleaching Corporation. This bleaching cell still stands and is in use as a make-up tank and storage tank for chloramine solution, which is used to control the growth of slime in the groundwood white water system.

The original bleaching system of 30 tons a day capacity consisted of the Fletcher cell of three tons capacity, a pulp shredder, a conveyor that delivered the shredded pulp to the cell, a dump chest and two couch deckers, which were used for washing the bleached pulp, and from which the pulp was pumped to wet machines to be lapped out.

The bleaching was done with a bleach powder solution which was added to the pulp in the cell in the same manner that bleach liquor is now added to the pulp in the second stage of the present two-stage bleaching system.

The bleach powder was shipped to the mill in iron containers. A measured amount of the powder was dumped into a mixing tank, where it was dissolved in water, allowed to settle, and the clear solution decanted to a storage tank, from which it was pumped to the bleaching cell.

The bleach mixing job for the old system was a very disagreeable one. Handling of the bleach powder, commonly known as chloride of lime, a white, ill-smelling, powdery substance, was quite unpleasant.

In 1928, construction work began on the present bleach plant which was put into operation in June, 1929. The equipment at that time provided for a production rate of about 80 tons a day. This has been stepped up by the installation of additional cells and equipment to the present production capacity of 150 tons a day.

The rapid growth of pulp bleaching as an industry is well illustrated in the Camas plant, which has developed from the 705 tons production in the year 1925 to the present 1938 annual production rate of about 35,000 tons.

The improvements in the operation are illustrated by the fact that in 1925 the average chlorine usage was 12% by weight of the pulp bleached, while now we are bleaching with a chlorine usage averaging 6.5% by weight of the pulp bleached.

The improvements in color and strength of the bleached pulp cannot be compared, dating from the first installation, because only in the past eight years or so have comparable records of strength been kept; and only in recent years has suitable equipment been available to so evaluate the color numerically that actual records could be kept.

Perhaps the greatest single advance in our bleaching operation affecting strength and color was the installation in 1937-38 of the two-stage bleaching system.

The single stage process is still widely used for pulp bleaching. Many plants today, such as those making high alpha pulps, use a three-stage bleaching process similar to Camas operations except that an alkali treatment is used as an intermediate stage. For pulps more difficult to bleach to a full white color, some mills are using a four-stage process. Some mills in Europe are reported to be using up to six stages for kraft bleaching. Careful investigation has shown, however, that the two-stage process now used is adequate for our present requirements.

Definition of Bleaching

The bleaching of pulp, as carried out in the two-stage system, may be defined as the destruction by chlorination in the first stage, followed by chlorinating and oxidizing chemical action in the second stage, of the impurities that are in combination with, or that accompany, the cellulose itself. These impurities consist of lignin and coloring matters that are incompletely removed from the pulp during the cooking process. Since it is cheaper to remove the lignin in the digester than in the bleach cell, a primary requisite for an efficient bleaching operation is to have a pulp with the proper balance of strength and bleach requirements.

Chlorine gas used in the first stage acts directly on these impurities to form yellow lignin chloride compounds that are soluble in water, and which are washed from the pulp. If these soluble compounds were not washed out of the pulp, the oxidizing action of the second stage would expend itself first on decolorizing them before fulfilling its primary purpose of bleaching the residual lignin.

Bleach liquor used in the second stage acts on the remaining impurities and to some extent on the cellulose itself. The substance formed when bleach reacts with cellulose is called oxycellulose, which is a decomposition product of cellulose. Its presence in the bleached pulp represents a loss of raw material, produces low color and low strength, and is the result of what is generally termed "over-bleaching."

The severity of this over-bleaching depends upon the amount of bleach used, the bleaching time, and the temperature and alkalinity of the pulp

during the bleaching operation. Temperature is particularly important.

When bleach liquor is added to pulp, the calcium hypochlorite breaks down to supply the chlorine. This removal of chlorine then leaves the lime again in solution. As the lime accumulates, it acts as a buffer to stop the reaction of chlorine and lignin. The reaction between chlorine and lignin can be prevented by the addition of an excess amount of calcium hydroxide. When this is done commercially, it is known as alkaline bleaching.

The calcium hypochlorite $\text{Ca}(\text{OCl})_2$ then breaks down to supply oxygen and the oxidizing action takes place. The oxygen obtained in this way is the active bleaching agent in the second stage of the process.

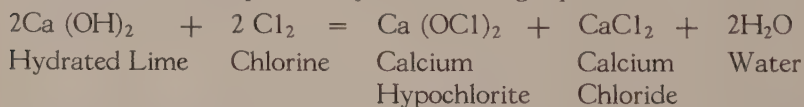
The calcium hypochlorite does not react with the organic materials, but it does provide a supply of active chlorine or oxygen.

Lignin appears to exist in two forms in pulp. Part of it is in an active form, attacked almost immediately by the chlorine. The rest is in a so-called inactive form that is chlorinated and oxidized much more slowly.

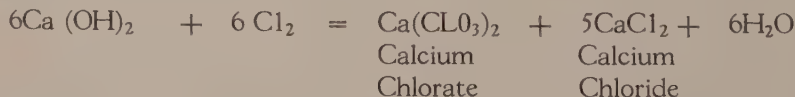
Manufacture of Bleach Liquor

Bleach liquor, or calcium hypochlorite, is made by absorbing chlorine in a suspension of hydrated lime or "lime slurry." In this process the temperature should be kept below 35°C . and an excess of lime must be present, or the hypochlorite will begin to decompose with the formation of calcium chlorate, $\text{Ca}(\text{ClO}_3)_2$ and excess chlorides. These compounds are of no value in the bleaching process and represent a direct loss of lime and chlorine.

The reactions are expressed by the following equations:



Further chlorination or high temperatures result in the following reactions:



The Chlorinating System

Chlorine from the storage tank cars flows in liquid form to the evaporators. This apparatus consists of a pressure tank surrounded by a hot water bath. The water is heated and circulation provided by means of a steam injector, the steam control to the injector being regulated by a

thermostat so that the temperature of the water can be held constant at 180° F. when chlorinating. The chlorine gas leaving the evaporators enters the pressure reducing valves.

The chlorine pressure up to this point can never exceed the pressure of the supply of liquid chlorine as long as all valves in the chlorine lines are open. As the pressure varies with seasonal changes and decreases as the contents of the car diminish, it is necessary to provide a means of maintaining a constant pressure through the Venturi throat, hence the pressure reducing valves. These are of the diaphragm type and have a capacity range of from 200 to 6,000 pounds of chlorine per 24 hours. A connection for steam is provided so that the valve can be heated, preventing liquefaction of the chlorine when gas having a high pressure is delivered to the valve.

The chlorine next passes through the Venturi type flow meter. This meter consists of a Venturi throat across which differential pressures are indicated on a manometer, with parts connecting to the entrance and throat of the Venturi meter. The manometer consists of a large outer tube to which the entrance to the Venturi meter is connected and a small inner tube which connects to the throat of the meter.

The higher pressure from the entrance to the meter communicates with the liquid in the large outer glass tube, forcing this liquid down and causing it to rise in the small inner tube. This differential head is a direct indication of the rate of flow and is measured by a graduated scale attached to the manometer tube. Carbon tetrachloride is used in the manometer to indicate the differential pressure. The chlorine then flows through the valve which controls the rate of flow through the meter, and from there to the point where water is injected into the line. The purpose of the water injector is to form a chlorine emulsion. The finely divided particles of chlorine in this emulsion permit more uniform mixing in contact with the pulp than would be provided by allowing the chlorine gas to flow directly into the stock.

There is a loop in the chlorine line just ahead of the water injector. The down side of this loop is made of two inch pyrex glass and a vacuum breaker is located at the top of the loop. When the chlorinating equipment is shut down, the chlorine gas remaining in the system cools; and the shrinkage in volume and reduction in relative pressure thus occurring in the line tends to allow the water and stock from the chlorinating tower to be forced back through the chlorine system and up the glass tube until it reaches the vacuum breaker. This vacuum breaker consists of a container in which a float operates. As the back flow of water raises the float, a needle valve is opened. This allows air to enter the line, which breaks the vacuum and equalizes the pressure, thus preventing water and stock from getting back into the iron lines and flow measuring equipment.

The most important rule of operation of the chlorine equipment is never to allow moisture to come in contact with the chlorine in the iron system. The reactions that would follow would soon destroy the lines, valves and flow measuring equipment.

Raw Materials

Chlorine is purchased as a liquid and shipped to the mill in tank cars from one of the several electro-chemical companies operating on the Pacific Coast. Manufacture of the chemical is accomplished by passing direct current through a saturated sodium chloride solution. The chlorine gas evolved is cooled and then thoroughly dried by contact with concentrated sulphuric acid. The dry gas is purified then liquified by compressing and refrigerating. From the refrigerating coils, chlorine is loaded into storage tanks or tank cars. Tank cars of chlorine arriving at the mill usually carry pressures of from 75 to 100 pounds. The chlorine at this pressure in liquid form readily changes to gas when the pressure is relieved. Each car is equipped with four discharging valves and a safety valve. This safety valve is set to relieve part of the contents of the car to the atmosphere if the pressure within the car exceeds 225 pounds. Immediately upon receiving an empty car back from a customer the chlorine company removes all valves from the car and gives them complete overhauling. They are then tested before placing them on a car which is to be filled with chlorine for shipment.

Care is taken in handling chlorine, as a broken valve or chlorine line can produce serious results in the mill and in the immediate environment of the mill.

The gas, two and one-half times heavier than air, is greenish-yellow and has a characteristic suffocating odor. Liquid or gaseous chlorine is not explosive nor inflammable and, in the absence of moisture, is not corrosive; but in the presence of moisture and heat it becomes reactive with nearly all substances.

The bleach plant is equipped with ventilating systems, but, as a precautionary measure, signs are prominently posted stating that chlorine tends to settle to the lower floor and warning against entering the building if chlorine can be strongly detected.

Splashes of liquid chlorine and chlorinated water destroy clothing and will cause irritation and acid burns if in contact with the skin.

Lime

The lime (calcium oxide, CaO) is purchased from manufacturers of the material and shipped to Camas in carload lots of 40 tons, put up in paper sacks containing 100 pounds each.

Operating Procedure

The batch system is used in making the bleach liquor.

The operator begins by weighing out 4,000 pounds of quicklime, CaO . He then slakes the quicklime by dumping it into a tank of 1400 gallons capacity, equipped with an agitator and a grate to collect the large insoluble

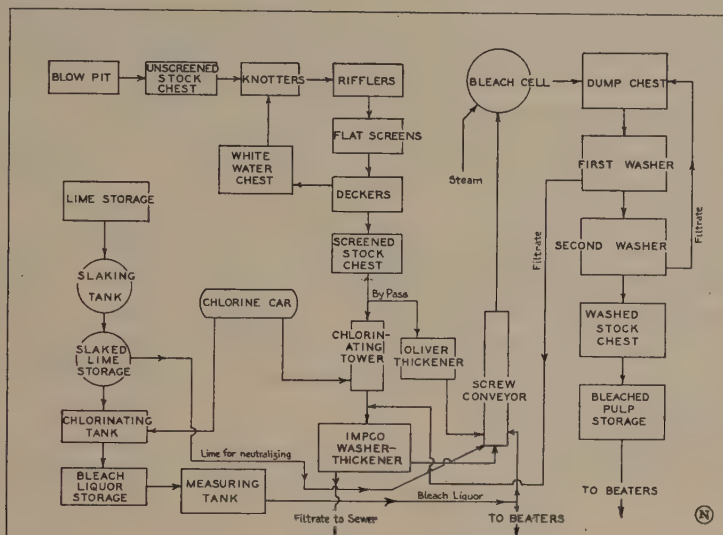


Fig. 65 Flow Sheet of Bleach Plant

particles. The tank is filled about half full of water before the lime is added. The lime is rapidly hydrated by the water, forming the hydroxide, $\text{Ca}(\text{OH})_2$, and generating considerable heat.

The slaking is carried out with the least water possible as it has been found that this will result in the hydrated lime breaking up into the smallest particles possible, which results in the most complete utilization of the lime in the chlorinating stage.

When the temperature of the slaking tank stops rising, the operator knows that the lime is completely slaked and he then dilutes the batch to the required strength of four pounds of lime to one gallon of water in the lime storage tank which is also equipped with an agitator to keep the fine particles in suspension.

Only a small part of the hydrated lime dissolves in water, the rest remaining in suspension.

The next step in the operation is to pump the "lime slurry" to the rectangular concrete chlorinating tank, which is equipped with an agitator and a special lead alloy chlorine line running from the bottom of the tank

to a connection with the main chlorine line leading from the tank car.

There are four of these chlorinating tanks in service, with two more to be equipped with agitators and the necessary piping if needed.

The lime slurry is diluted to the proper volume (16,000 gallons) using the wash water from a previous batch. The agitator is then started and the chlorine turned on. Chlorination is continued until the bleach liquor tests 0.3 pounds of available chlorine per gallon, the required amount of lime having been added at the start so that at this point there is still a small amount of free lime remaining that has not been chlorinated.

From $1\frac{1}{2}$ to $2\frac{1}{2}$ hours are required to chlorinate a batch depending upon the pressure in the tank car. Agitation is then stopped and the sludge allowed to settle.

The clear bleach liquor is decanted by means of a swivel pipe, thus leaving the layer of settled sludge undisturbed. The liquor flows by gravity to the storage tanks directly below; and from these tanks it is pumped to the measuring tanks above the bleach cells, from whence it is measured to the cells, or to the beater room for usage in beater bleaching kraft pulp.

Sludge Washing

The sludge consists mainly of calcium carbonate, hydrated lime, some active bleach liquor and impurities such as sand and other insoluble material.

The hydrated lime and active chlorine remaining in the sludge are recovered by filling the tank half-full of fresh water, agitating and again allowing the insoluble calcium carbonate to settle. The clear wash water containing the recovered chemicals is decanted off and used to dilute the next batch of lime slurry to be chlorinated. Each sludge is given two or three such washings before the insoluble calcium carbonate is drained to the sewer. In this way all but a very small amount of the hydrated lime and chlorine is recovered from the sludge.

The calcium carbonate in the sludge is formed by the action of carbon dioxide in the air on the quicklime during the time the quicklime is in storage. Its formation results in a definite loss of material.

Pulp for Bleaching

Pulp for bleaching can be obtained from any of the ten digesters in the sulphite mill. The usual operating procedure is to bleach the pulp from No's 1, 2, 3, 4, 5, 8 and 9 digesters, leaving the larger digesters, numbers 10 and 11, to supply the unbleached requirements of the paper mill. This affords a more uniform flow to the machines using this unbleached grade and at the same time affords more flexibility by furnishing stock from the

smaller digesters to the bleach plant. For example, if a special grade is required and No. 1 digester is selected for its production, and the stock produced does not meet requirements, the next digester can be scheduled for this grade and there is only a small amount of pulp to divert over the wet machines.

Occasionally special grades are required, such as cottonwood or other pulp cooked to different degrees of delignification. These grades are made in any digester convenient, depending upon factors such as the time the pulp is needed and the quantity desired.

Bleaching Operation

Pulp from the digester is washed thoroughly in the blow pits and pumped to the knotters, riffles and flat screens, where the knots, dirt and coarse fibers are removed. It is then pumped to one of the 25-ton capacity outside storage tanks, of which there are two, numbered 14 and 15. From these tanks the pulp is pumped to the chlorinating tower.

First Stage Chlorination

A gooseneck is provided in the stock line between the storage tank and the chlorinating tower, the top of which extends up above the stock outlet on the tower. In this way a constant head is maintained for the flow of stock through the tower. The operator regulates the flow of stock to the tower by means of a valve located at the top of the gooseneck.

The chlorine gas, mixed with water, is admitted to the stock on the down side of the gooseneck and pipe lines to the bottom of the tower.

The operator adjusts the chlorine flow to the stock by means of periodic tests made on the chlorinated pulp leaving the tower. These tests tell him the percentage of the total amount of chlorine needed to bleach the stock that he is using in the first stage. He adjusts the flow until by testing he knows that about 60 percent of the total chlorine demand is being used in the chlorinating tower.

The chlorinated pulp is forced up through the tower at the rate of about five tons per hour, allowing the pulp a retention period of about fifteen minutes in the tower as it passes from the bottom to the top.

The stock flows out of the top of the tower to the headbox of the washer-thickener. The washer section removes the impurities rendered soluble by the action of the chlorine in the tower. The thickener section presses water out of the pulp to the required consistency in preparation for its treatment in the second stage bleaching in the cells.

The pulp is neutralized as it leaves the washer-thickener by adding a solution of hydrated lime. The amount of lime added depends upon the

amount of chlorine being used in the tower and is controlled by a test made on the pulp at the end of the second stage bleaching period.

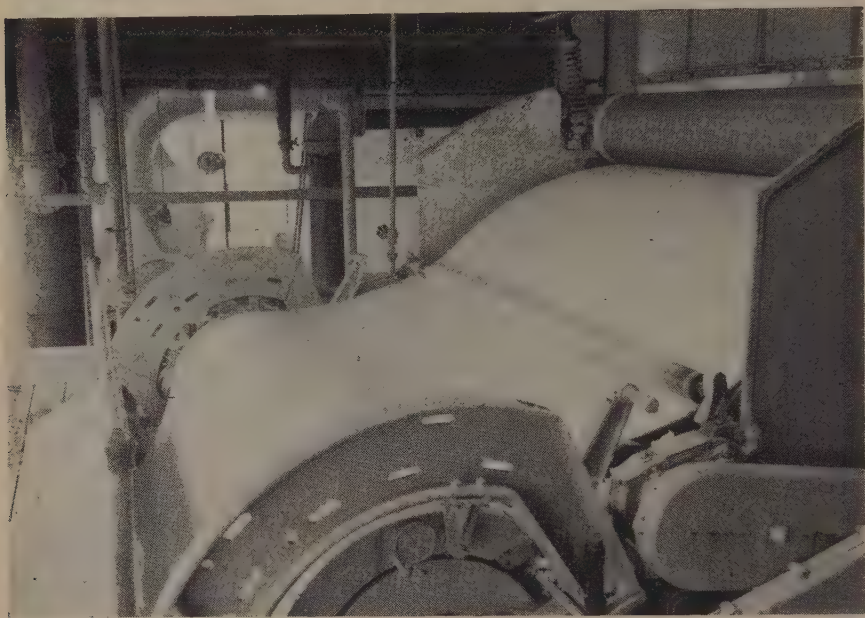


Fig. 66 Washer Thickener

It is desirable to keep the pulp on the "alkaline side" throughout the bleaching period in the cells, so enough lime is added to accomplish this. The relatively large amounts of hydrochloric acid formed in the first stage have to be removed as soon as possible by washing and neutralizing to prevent corrosion.

From the second section of the washer-thickener the pulp drops into a screw conveyor which delivers it to the cells.

Second Stage Bleaching

Bleach liquor is added to the pulp as it enters the screw conveyor. The amount of liquor added is determined by the same test made on the pulp to determine the amount of chlorine to add in the first stage chlorination.

The pulp containing the bleach liquor enters the bleaching cell for its second stage treatment at a consistency of about 14 percent.

The bleaching cells, of which there are seven in service, are a modification of the Fletcher high density bleacher, known as the VW Bleacher. They are tile lined and have a central tube with a screw and plow that

follows the contour of the bottom. The plow sweeps the pulp into the screw which forces the pulp up the inside of the tube and out at the top.

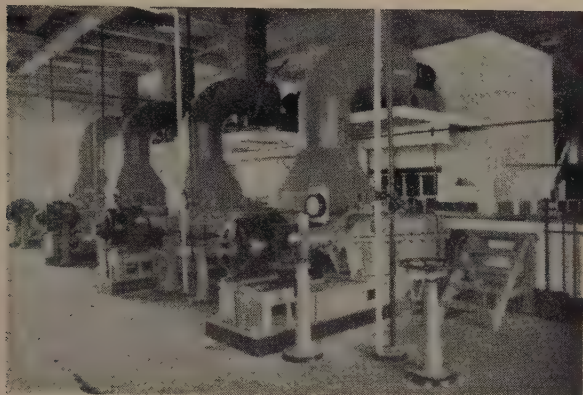


Fig. 67
Driving Heads
of Bleach Cells

A bonnet is mounted at the top which spreads the pulp out towards the walls of the cell. The circulation in the cell is at the rate of one complete turnover of the stock every nine minutes. The action of the plow and screw tends to squeeze the liquor out of the stock. The pulp passing up through the screw is drier than the pulp outside the tube. When it reaches the top it expands and on the way back down it picks up more liquor. In this way there is not only a mechanical turnover of the stock, but a turnover of the liquor as well. The result is a uniform distribution of the liquor and the squeezing action tends to force the liquor into the shives and fiber bundles. The result is that pulp bleached in this manner at high density is cleaner than pulp bleached at low density.

Steam is admitted to the bleach cell so that the temperature is brought up to a point not to exceed 105° F.

At the usual operating rate at Camas, a cell (4½ tons of pulp) is filled in 35 minutes. This filling time could be reduced, but it is as fast as the present (1938) pumps and washers will handle the bleached pulp.

After the cell is filled, about two hours and fifteen minutes are required to bleach the pulp to the required degree of whiteness. During this time the operator is constantly checking the progress of the bleaching action. He draws a sample from the cell and applies a test that tells him how rapidly the bleach liquor is being consumed. If this test shows him that the chlorine in the liquor is nearly exhausted, and a check on the color indicates that it is not bright enough for the liquor remaining to complete the action, he adds more liquor. The fact that a certain degree of brightness must be reached and still have a certain amount of residual chlorine present means that the

operator must keep a continuous careful check on the progress of the bleaching. If he does not have this residual chlorine present at the dump, the pulp tends to revert in color in the storage chests. Too much residual chlorine is, of course, a waste of material in addition to involving the hazard of pulp degradation.

When the proper point is reached, the batch is dropped into a dump chest directly below, where it is diluted with water to a consistency of about 2.0%. Since ordinary concrete is attacked by chlorine pulp mixtures, allowing sand to get into the pulp, this chest, like others in the bleach plant, is lined with white tile to prevent pulp contamination.

From the chest the pulp flows over vacuum type washers. There are two of these, size 8x10-feet, in series, with a diluting and mixing box between the first and second washers.

The pulp leaving the second washer drops into the wash chests below. There are two wash chests of ten tons capacity each, where the washed pulp is stored at about 5% consistency. From here the pulp is pumped to the bleached pulp storage chests or to the wet machines.

There are three bleached pulp storage chests, numbered 17, 18 and 19, each of approximately 18 tons capacity.

The present method of operation is to use No. 19 storage chest for the No. 1 grade of high test bleached pulp. This chest supplies all paper machines excepting No. 6. If there is any difference in test, the pulp testing the lowest of the high test grade, is pumped into No. 17 storage chest, which also supplies all paper machines excepting No. 6. This pulp is used in grades of paper for which it is suitable.

Special grades of bleached pulp are pumped to No. 18 chest, which supplies Nos. 1, 2, 9, 10 and 11 paper machines.

Filtered water is used exclusively throughout the bleaching operation for fresh water requirements. The filtrate from No. 1 Oliver washer is used for dilution purposes in the headbox of the Impco washer-thickener, and the filtrate from No. 2 Oliver washer is used for dilution purposes in the dump chest.

Water legs supply the vacuum for the cylinders of the two washers and for the cylinder on the washer section of the Impco washer-thickener. A Nash pump supplies the vacuum for the cylinder of the thickener section of the washer-thickener, and for the old Oliver thickener which is used for special stock not requiring two-stage bleaching.

Control

A system of control is maintained by the Technical Department.

Records are kept in chart form covering the following phases of the operation:

1. Excess lime at end of chlorination (in bleach liquor making).
2. Excess chloride (in bleach liquor making).
3. Chlorine loss in storage (bleach liquor).
4. Chlorine loss in sludge (bleach liquor).
5. Total chlorine consumption (bleaching pulp).
6. Chlorine consumption:

First stage.

Second stage.

7. Consistency of pulp entering washer.
8. pH of pulp in wash chests.
9. Strength and color quality of bleached pulp

CHAPTER X

SCREENING

By F. R. SIEVERS

Brief History of Screening

Years ago there were no screens. An effort was made to keep the paper free from the mechanical impurities we now call dirt by careful preparation of the rags from which paper was then made. The lumps and knots were removed from the paper, not before, but after it was made. The sheets were gone over by hand and the knots removed by picking them out with a penknife.

The first screen of which we find any record is one invented by Richard Ibotson of England about 1830. This was a screen in which the box containing the plates was vibrated. It was the forerunner of the knocker type of flat screen, which was almost exclusively used in this country up to about 1890 to 1895. The diaphragm screen soon followed, but it was not perfected and had no great sale, while the vibrating screen flourished. When it finally did receive recognition, it quickly replaced the vibrating screen. For one thing, it was very much cheaper, both as to manufacture and use; for another thing, it was about that time that wood pulp came into widespread use, and the conditions of screening were easier. With all its noise and expense, the knocker screen had a highly developed ability for putting long rag stock through fine cut plates.

Rotary screens date back to about 1860, when Christian Wandel, a German, invented the original Wandel screen, an outward flow type. About the same time, there were invented inward flow rotary screens of which George Bertram, of Edinburgh, brought out one of the earliest, if not the first.

Following the development of wood fiber and the establishment of pulp mills as a chief source of supply for papermaking fibers, entirely new demands were made on screening apparatus. This does not seem to have been quickly realized, and for what seems like a long time, the pulp mills used exactly the same kind of screens as were used in paper mills, first knocker screens and later flat diaphragm screens. It was really the beginning of the present century before screens were developed for particular needs encountered in the screening of pulp, and it is only in the past twenty years that pulp screens have been a great success. It is perhaps worth mentioning as a point of difference between earlier screening methods and those of the present day, that, up to thirty years ago, one type was gen-

erally used for all kinds of stock and conditions of screening. Today, there is a type of screen which is purposely built for each type of work.

Coarse Screening

In all screening systems, coarse material must first be removed by a preliminary screen before passing to the fine screen. In some mills, especially in Europe, pulp is divided by screening to two or three classifications, knots and slivers being removed first with intermediate screens, giving a pulp usable in board and coarse papers, and lastly, fine screens which give a fine fiber pulp to be used in the better grades of papers.

Types of screens used for coarse screening vary. In the sulphite and kraft processes, they are usually spoken of as knotters. In the groundwood process, the coarse screens are usually known as "Bull screens." Perforations of the plates in bull screens usually run from $\frac{1}{4}$ " to $\frac{3}{8}$ " in diameter. Power used is small, usually from two to three continuous H.P. for screening thirty to fifty tons of pulp. The bull screen at Camas is six feet long, curved on a four foot radius and has $\frac{1}{4}$ " perforations spaced $\frac{3}{8}$ " apart.

Of the several types of knotters, the worm and rotary are most generally used, although flat knotters have in recent years found much favor with producers of high grade sulphite pulp.

Worm Knotters

The worm type knotter is built in the form of a hollow wire covered cylinder supported upon trunnions, so that it can be revolved in a vat. One end of the cylinder is partly closed and receives the pipe supplying the pulp. The cylinder is supported and strengthened longitudinally by a number of truss rods. The entire body of the machine between the heads is constructed of bronze or copper. All bolts are bronze. The worm of the cylinder, from whence the name of the machine, is of copper, while the vat is of tongue and groove wood. The knotter plates, which form the cylinder, have a large number of $\frac{13}{16}$ " x 2" slots. These openings are sufficiently large to allow the desirable material to pass through into the vat from which it may be piped as desired. The rejected material is discharged at the outlet end over a projecting ring of copper after travelling through the worm. This type of knotter is sprocket driven, the sprocket being attached to the inlet end. Very little power is required for operation, but the disadvantage of this type of machine is the floor space required per ton of pulp screened. This type of knotter screen is not used at Camas, although it is adaptable to any of the processes, i.e., it may be used as a sliver screen in the manufacture and refining of groundwood pulp or as a knotter screen in the sulphite and kraft processes.

It will be noted that all surfaces with which the pulp comes in contact are of wood, copper or bronze. In pulp screening equipment, it is necessary to avoid contact of pulp with iron due to tendency of small amounts of dissolved iron to darken the pulp by formation of "inks," or iron tannates.

Impco Knotter

In the coarse screening operations at Camas, centrifugal knotters are used in both the kraft and sulphite screen room. This type knotter is so designed that the machine has only two bearings subjected to mechanical wear and these are ring-oiling. Likewise, the shaft supporting the screen

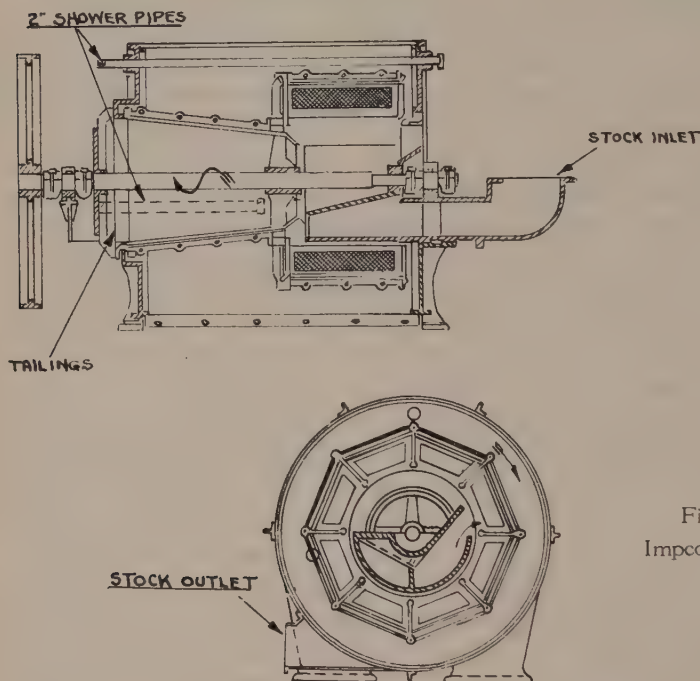


Fig. 68
Impco Knotter

revolves so slowly that these bearings will wear indefinitely. The screening cylinder is built up in the form of an octagon with plates of sufficiently large openings to allow the good fiber to pass and to reject the knots and undesirable material. This cylinder is enclosed within a specially designed casing near the bottom of which is located a good sized outlet opening for the accepted pulp. The inlet end of the screening area is larger in diameter than the area near the sliver or knot outlet and is otherwise specially designed for the efficient separation of the good pulp from the rejects. Water with sufficient pressure is used to properly dilute the pulp and to aid in the separation of the good fibers from the rejects.

This type of screen is now being extensively employed as a first or coarse screen on all grades of pulp because of its large capacity, small power requirements, and the very small floor space required for complete installation. The manufacturers claim a capacity of 50 tons per 24 hours of operation with a consumption of power not to exceed two horsepower.

All centrifugal knotters are operated in about the same manner and have, in general, the same basic design. The screen plates used by various individual manufacturers all have openings large enough to allow the good stock to pass through, yet small enough to reject the large knots and uncooked fiber. Great care must be exercised in providing a sufficient shower of water to the fibers while they pass through the knotter, so that no good fibers adhere to the knots and uncooked wood. This showering is very important to secure economical operation without losing an excessive amount of good pulp.

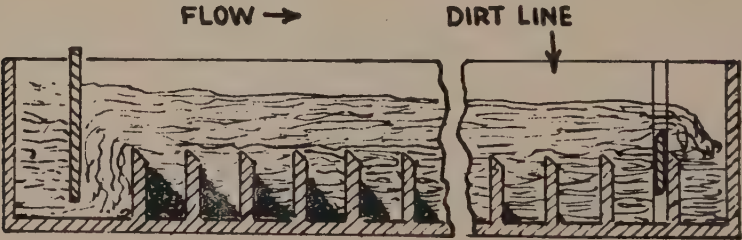
The knotters just described are usually used on chemical pulp but in late years have become quite extensively used to remove slivers from groundwood. The common screen used to remove coarse material from groundwood usually consists of a half circular perforated plate upon which the pulp flows and a revolving brush to keep the plate clean so that the finer fibers may readily pass through into the pulp system. In this screening operation, the stock must be diluted to a consistency of not higher than 1%. In chemical pulps going to the knotters or coarse screens, the consistency is usually from 0.5% to 0.75%. This lower consistency is generally used with chemical pulp due to the fact that the fine fiber is longer and will cling to the refuse matter more closely than will the shorter groundwood fibers.

The coarse stuff having been removed, the pulp is pumped directly onto the fine screens. The water is used over and over again, forming an endless belt carrying the pulp through the screening system to the deckers where the water is removed and sent back to the pulp mill again to be loaded to resume the same journey.

Rifflers

Rifflers, or as they are more aptly called in Europe, "sand catchers," are primarily used to rid the pulp of sand and other heavy material which is undesirable in the manufacture of high grade pulp. Frequently, as at Camas, the mill is so designed that the riffler installation is adjacent to the knotters. The usual type of riffler is made of one or more shallow horizontal troughs. It is really a shallow wooden sluice 6 or 8 feet wide. Baffles are placed all along the inside bottom of the rifflers, opposed to the flow of pulp. In some installations, the baffles are inclined against the flow, or

they may be inclined with the flow of pulp. It is advisable to build the riffler in many partitions, so that one part may be shut off for cleaning without interrupting the operation of the plant. The capacity of a riffler installation should be large enough to handle all of the pulp manufactured. A large area is required for a riffler installation and for that reason many mills are not equipped with rifflers since the amount of material removed from the pulp is not sufficient to warrant the expenditure and the space necessitated by them. Ordinarily, the longer the riffler, the better it is for doing efficient work. The rate of flow of pulp and consistency are important considerations. The current should be leisurely—about forty feet per minute. Generally speaking, it can be said that the slower the flow of pulp in the rifflers and the greater the length of the riffler bed, the better are the results obtained, although with a greater percentage of rejections. The depth of the riffler is, likewise, dependent upon available space. In any installation, special provision should be taken to make cleaning an easy and quick operation. In some instances, the system is so designed that the cleaning operation is very simple. It is only necessary to close the pulp inlet, admit water, and stir up the knots and sand below the baffles. This allows any good fibers which may be present to flow off with the water. After all the good fibers have been removed, the water is shut off, one side of the riffler is raised, and the sand and knots are hosed out into spouts along the side.



CROSS SECTION OF RIFFLER TROUGH

Fig. 69

In some installations, the rifflers are lined with felt. The felt is supposed to catch and hold the dirt as it settles to the bottom. Rifflers of this type are usually used after the pulp has been screened and where an absolute minimum of dirt is required, such as in bonds and ledger papers.

For use on groundwood stocks, the most satisfactory riffler has been found to be one where the stock falls with a small drop from one partition to the other. This small fall gives an agitation that washes the sand loose from the fibers so that it has a chance to settle. In a slow flowing riffler

pond, sand is carried by the fiber which acts as a raft for the sand.

Fine Screening

Usually, after the knoter and riffler operation, the pulp is in condition for fine screening. Fine screens have been built on many different principles. Screening by shaking, water shock, gravitation, centrifugal force and suction have all been tried, but the screens that have been found the most practical and are used in most of the mills are of two types—the diaphragm and the centrifugal.

Diaphragm Screen

Diaphragm screens are often referred to as "flat screens" and are preferred in mills making high grades of pulp. They also are widely used as tailing or secondary screens in nearly every type of screening system. This is due to the fact that the trough-like surface of the screen itself allows the use of enough water to flush over dirt and undesirable matter found in pulp more readily than any other type of screen. One of the drawbacks of these screens has been the high cost of upkeep.

At the present time a great deal of improvement work is being done on this type of screen due to the fact that, having once been displaced largely by centrifugal screens, they are coming back into broader use, particularly in sulphite mills. Flat screens consist of slotted metal plates fastened in the bottom of a wooden vat, either with screws or in some cases with patent fasteners that allow for more rapid changing of plates. The bottom frame of the screen on which the vat that holds the plates rests is

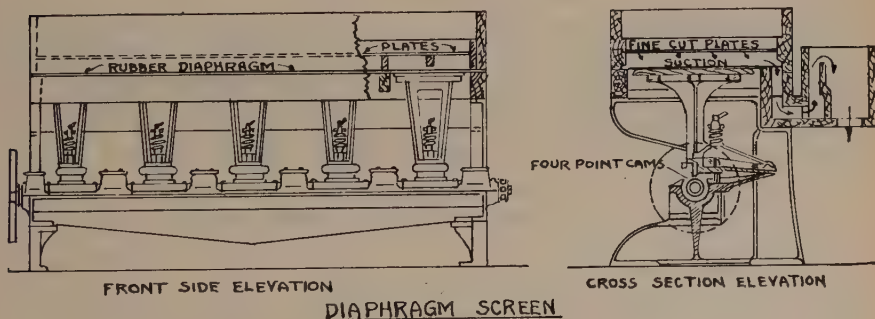


Fig. 70

made up in sections, on the bottom of which are sheets of heavy rubber and canvas fabric, called the diaphragm, fastened at the edges. The diaphragm can be vibrated up and down by a pitman connected to its center part and pulsated in the ordinary screen by a shaft on which is mounted a cam that gives this pitman an up and down motion, causing the rubber sheet to have a pumping action. Fig. 70 shows the side boards of the screen,

the position of the plates on the screen, the rubber diaphragm, the pitman which actuates the diaphragm and the shaft on which are located the cams.

The cams used for this purpose usually are called three or four point; that is, there are three or four high places on the cam that makes the screen diaphragm rise three or four times to a revolution of the shaft. This allows the shaft to be revolved at a fairly low speed, and still gives a great many pulsations to the diaphragm. The stroke of this cam is so figured that it is supposed to raise the diaphragm from $\frac{1}{8}$ " to $\frac{3}{8}$ "; however, the amount that the diaphragm deflects up and down is more or less a matter of conjecture as the pitman is forced down by a spring, and unless the strength of the spring is excessive, the toe part of the pitman may not be held continually against the cam but may only hit the high parts, possibly cutting the length of the stroke in half.

In this screen, the chamber between the plates and the diaphragm is hermetically sealed when it is working. The stock outlet at one side of the screen is so made that a water trap is formed so that no air can enter. The layer of stock and water passing over the plates prevents air from entering at this point.

Thus, when the diaphragm is forced down, suction is formed which draws stock and water through to pass from the screen by the gate at the side. On the upward thrust of the diaphragm, water is forced up through the plate slots, causing the coarse pulp and dirt, not wanted, to be raised and floated on down the screen. This action takes place 400 to 600 times per minute in the average screen. The screen chambers must be filled with water before starting up or the screen would not work. Should the under part of the plates be filled with air, which is easily compressed, the slight throw of the diaphragm would have no effect on the pulp passing over the plates. A screen in this condition is called "air bound." Any air leaks in screens cut down production. A modern mill in the East made a recent survey of their screens for losses caused by air leaks and after closing all leaks found the efficiency of their screens increased 15%.

For a long time, screens were built with the idea that a long slow stroke and relatively rapid upward thrust would result in the greatest screening capacity; however, this does not seem to be the case in all instances. For example, where flat screens have been speeded up, production has been increased even at points where the toe of the pitman could not possibly follow the contour of the cam. In the original installation of these screens, the end of the pitman was fitted with removable blocks which rapidly wore out and caused a great many replacements. Toe blocks of a rolling type have come into use in recent years and have to a great extent done away with this matter of frequent replacement of these blocks.

Following this was the so-called positive action screens on which an eccentric bearing was placed on the shaft in place of a cam, giving a more positive throw to the diaphragm. This positive throw type of screen, while it has met with some success, after changes made from its original construction, has not been completely accepted as the final improvement in flat screens. This type of screen, often looked upon as a very elementary type of screen, when gone into scientifically, is found to be really a most complex type of machine. It embodies the action of pressure and suction through vacuum chambers, together with the use of vibration, and thus compounds a number of basic mechanical features which seem to be necessary to give good production yet produce clean pulp. The latest development in this process that rather explodes some of the old time ideas is the use of a pulsator known as the G.I.W. drive. The G.I.W. drive consists of two "off-balance" fly wheels that counterbalance each other except at the top and bottom of each revolution, where the counterweights giving the off-balance are in the same relative position, thus giving an upward thrust when on top and a downward thrust when both weights are on the bottom. This action, instead of occurring at the rate of 400 to 600 vibrations as used in the ordinary type of screen where we have a shaft speed of 110 to 260 R.P.M., has been found to be more effective when the number of vibrations is increased to about 1500 per minute. This development is not yet complete, but should it prove as favorable as is now indicated, it should eliminate a great deal of the heavy repairs which seem to be a part of flat screen operation.

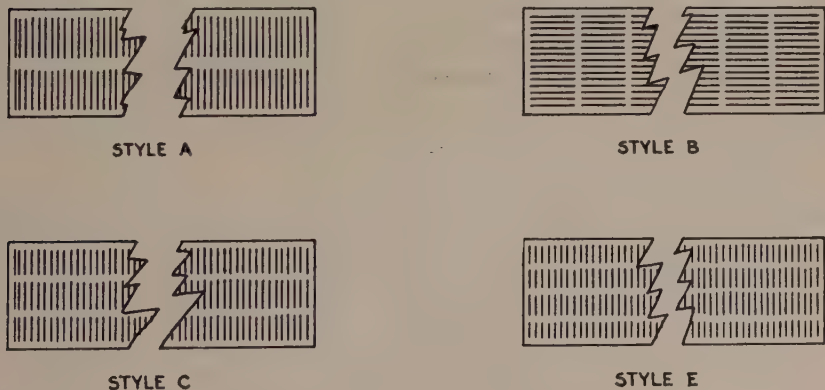


Fig. 71 Standard Styles of Screen Plates

Plates used on flat screens vary in size. The size used at Camas are 12" x 43" x $\frac{3}{8}$ " thick. In these plates are cut slots varying from 6 to 4 slots per inch, and the direction that the slots run is either with the length of the

plate or across its face. Types of screen plates are designated as A, B, C, E. The A type plate has two rows of slots, which take up the full width of the screen and are cut crosswise of the plate. In the B type, the slots are cut the long way of the plate, and are usually 4 to 6 inches in length. The C type has three rows of slots, with the slots cut crosswise of the plate. The E type which has four rows of slots, is the type we have found most desirable for producing clean pulp in the Camas mill.

SCREENING CAPACITY

Using Style "A" cut 4 slots per inch as a standard				
	4 Slots per inch	4½ slots per inch	5 Slots per inch	6 Slots per inch
Style A	100%	112%	125%	150%
Style B	94%	105%	116%	137%
Style C	88%	98%	110%	132%
Style E	8 Slots per inch—165%		6 Slots per inch—124%	

The "cut" of flat screen plates is designated as the width of the slot in thousandths of inches. For example, no matter in which direction or how many slots there are, the plate is called an 8 cut if the slots are .008" wide.

Stock must be brought to these screens at a very high dilution, usually 0.2% to 0.3% consistency. The screens are showered, these showers serving to wash the coarse stuff down the plates to the end of the screen where it runs over and is carried to the secondary screen where it is rescreened, usually through finer plates which take out all the stock that may be left in the first screening.

Screen plates must be taken up at quite frequent intervals and the slime and waste that gathers from pitch and decomposed substances washed out of the vats. Screens of this type require constant supervision while working, and constant inspection due to the fact that should a plate come loose or a slot bend open foreign material would enter the accepted stock and destroy it for commercial use.

Flat screen plates are usually made from bronze or brass. Formerly, nearly all plates were made from this metal but due to advanced scientific research, new metals have been tried. Monel metal has been used but cost has restricted its use. Stainless steel plates are now being used and in some cases have been reported as being very successful. Although those at the

Camas mill have shown no wear, for some reason they seem to have a lower production than other types of plates.

The most important development in recent years in screen plates has been the plating of the bronze and brass screen plates with chromium. Chromium plating has the following important advantages over regular bronze:

1. The metal is more resistant to corrosion.
2. Slots are smoother, free from microscopic tool marks which slow down production of cut bronze screens until broken in.
3. Chromium, being the hardest of all commercial metals, resists wear so that the slots do not gradually enlarge as they do in ordinary plates.
4. Chromium has a low coefficient of friction, thereby accelerating passage of fibers through the slots and movement of rejected material across the plate surface.

Chromium plated screen plates were first installed at Camas in 1934.

One of the big problems encountered in screening stock, not only in flat screens, but in all screens, is maintaining a uniform consistency of stock coming to the screen. A great deal has been done to develop a consistency regulator that would work effectively on low consistencies of 0.2% or 0.3% but without a great deal of success. Some of these instruments work when given constant attention but are not practical enough to be foolproof. Uniformity of consistency is important not only to regulate the washing action on the pulp but to control the effect of its variation on dirt. If a screen, running at 0.3% consistency is lowered to 0.2%, the amount of dirt washed through will be practically double that produced at the higher consistency. To guard against excess dirt due to these changes, a great many mills use plates cut as fine as .006". This has a serious objection in that it rejects the long fiber necessary in chemical pulps to give strength to paper and board and also will give more loss of good pulp. Until consistency regulators have been perfected, this plan will probably have to be followed. But should one be able to obtain constant 0.3% to 0.4% consistency on flat screens, it would be found that much coarser plates could be used, giving the benefit of the long fibers and at the same time the dirt could still be effectively eliminated.

Flat screens are usually arranged with 14 plates per unit, and at Camas there are four and five units in a line and eight lines in the complete installation. A new type of all metal bronze vat is used, which substantially increases the effective suction area under the plates and allows the plates to be securely fastened without troublesome bolts and screws which, in ordinary installation, becomes loosened by vibration.

In most mills, it is customary to graduate the size of plates in the screen line. For example, 8 cut plates may be used in the inlet sections, 7 cut in the middle sections, and finer 6 cut plates at the discharge end where the concentration of dirt is higher.

Centrifugal Screens

Centrifugal screens are divided into two types, the open type and the submerged type. In the open type, the pulp falls clear of the plate when screened, and in the submerged type the plates of the screen are wholly or partially submerged in the screened stock.

Open Type Centrifugal Screen

This type of screen is built in a cylindrical shape consisting of an inside casing in which are ports through which the stock enters, as shown in Fig. 72. The stock passes through ports in the ends of the screen housing

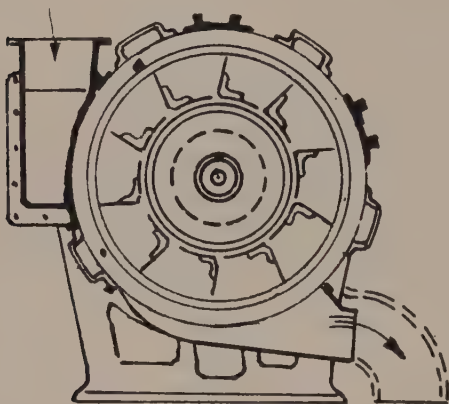


Fig. 72

CROSS SECTION ELEVATION CENTRIFUGAL SCREEN SHOWING IMPELLERS

to the revolving blades of the impeller, and is thrown against the screen plate. This plate is constructed of perforated metal having round perforations varying from 0.04" to 0.125" as required for the grade of stock.

The good stock passes through this plate into the discharge line.

The blades are so constructed that the stock is brushed to the end of the screen, where it is washed by a shower before the rejects are passed to the tailing screen.

The Reed Spafford screen is an improvement over the Impco centrifugal screen. A shower in the center of the sliver outlet retards and washes the slivers so that all good pulp is removed.

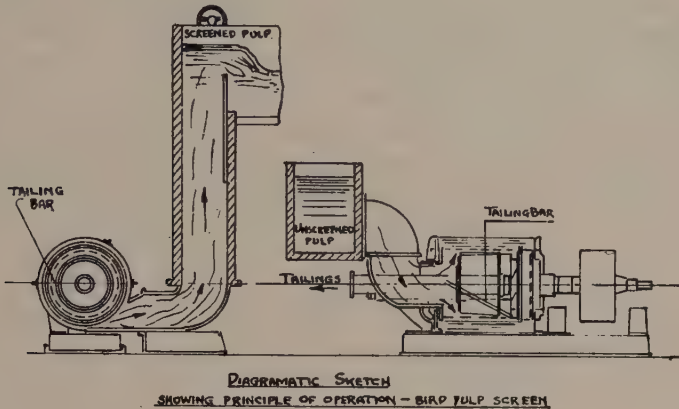


Fig. 73

Fig. 73 shows a type of screen where the plates are wholly submerged. In this machine, the screen plates are revolved. The stock enters the chambers formed by the screen plates as shown. The frames are so constructed that the plates form a cylinder with one end fastened to the shell casting which is driven from the pulley. The rotary action gives the screen a pumping action, enough so that the pulp is driven up the tower on the discharge side. As the plates revolve, the stationary bar causes the coarse pulp or rejects to be thrown to the pulley end of the screen, from whence they flow out through the outlet. On the end of this outlet is a receiving box with removable dams so that the height of the dam can be adjusted to retard the flow of the rejects from the screen so that they can be washed free of pulp.

Adjustments are also used on the tower and different heads are used for different kinds of pulp.

The screening operation in this type screen is performed by a continuous suction through the screen plates. This suction is produced by the revolving body of pulp on the outside of the drum, in the space between the drum and the casing. This pulp revolves with a speed nearly equal to that of the plates, developing centrifugal force, which pumps the pulp several feet above the center of the machine. The screened pulp flowing out of the casing has a tendency to produce a vacuum in the machine, drawing the pulp through the perforations. This is similar to the action of the "flat screen." The screening action of the Bird screen is much milder

than that of the impeller type, because the velocity of the screen plates of the former screen is considerably less than the velocity of the paddle tips of the impeller screen. The average speed at which the tips of the paddles of the impeller type of screen run, and which has been found most economical, is about 3,750 feet per minute. The velocity of the screen plates of the Bird screen, at a standard speed of 350 R.P.M., is only 2,470 feet per minute, creating a much gentler screening effect. In the Bird type screen, the screened pulp is backed up so that the unscreened pulp will not dry on the plates, and the fibers are kept in suspension. This eliminates dirt and slime. It is the same principle as that applied to the "flat screens", for when the dams on the "flat screen" are dropped, the pulp will thicken on the plates. The same thing happens on the Bird screen, for when the dams are dropped on the screened pulp, the pulp mats on the plates. The backing up of the screened pulp on the Bird screen also counteracts the suction due to centrifugal force of the revolving body of pulp outside the drum, and only the difference between the force urging the pulp out of the casing and the back pressure or head on the screened pulp, makes the pulp flow through the perforations. This force is relatively small compared with that developed by the impeller type screen, or by the "flat screen", where the pulsating action of the diaphragm is quite positive.

Screen Perforations

The smallest commercial screen perforation in use that can be supplied by plate manufacturers without an exceptional increase in cost is .040". This is used in many mills where a short fiber length is desired to mix with bleached pulps. However, a sliver as large in diameter as an ordinary pencil lead will pass through a .040" perforation, which indicates that some action within the screen prevents the passing of the slivers through the plate.

The reason that clean pulp can be screened through these openings, or any other perforations, is due to the longer fibers forming a sliver mat made up of rejections over the perforations, and screening is actually being done through a sliver mat. Pulp mills formerly produced enough slivers to form a mat on screen perforations of almost any size, but with the development of the pulp industry and the resulting reduction of the number of slivers, it has become necessary to use smaller perforations in the screen plates in order to realize the maximum screen efficiency. In reducing the perforations from .075" to .055" the area of the openings has been reduced 60%.

With the reduced opening it is found that rejects from the screens increase. Also, that there is a considerable amount of long fiber that should be saved that is carried out with the waste.

An ordinary procedure in a case like this is to increase the water to the screen. With a low consistency, it will be found there is less waste, but the amount of dirt will be nearly as great as with the larger opening in the screen plate.

It has been found that by increasing the consistency of the stock going into the screens much cleaner pulp can be obtained than by reducing the screen plates perforations to a point where excess water is necessary to force the stock through the openings.

Pulp is screened at consistencies of 0.25% to 0.99% in centrifugal screens and the sure method to insure a clean pulp from this type of screen is to increase the consistency of the stock to the screen.

The manufacturers of the Trimbey screen, which many people regard as a very successful screen, have carried this idea farther. Where the stock enters the screen, the perforations are relatively large, decreasing in size at the opposite end. This is possibly due to the fact that where the pulp first enters, long acceptable fibers help to form a pulp mat on the screen, but as the pulp travels along the screen plate, there is more danger of getting shives and slivers and the perforations must be decreased in size.

Deckers

It is necessary for economical handling and for convenience to thicken the pulp as it comes from the screens. Screened pulp generally has a consistency of from .25% to .60%.

A number of different types of machines are used for the thickening of such pulp to any predetermined consistency. The desired consistency depends upon how the pulp is to be handled prior to the beating operation. In some cases, it is simply necessary to thicken for immediate use in the beaters, while in other instances it must be concentrated for storage or shipment.

The decker is probably the best known machine employed in the industry for thickening pulp that is to receive further treatment within a comparatively short time. Although there are a number of different makes of deckers which vary considerably in design and construction, most of them operate on the same general principle. In short, a decker is simply a cylinder rotating in a vat filled with screened pulp, the cylinder being of such design that it picks up the stock and separates it from most of the water, after which the thickened pulp is removed from the cylinder face by some mechanical means. There are two general types of deckers employed in the Camas mill operations—the couch decker and the pneumatic decker.

Couch Deckers

The important parts of the couch deckers are:

1. Vat.
2. Cylinder mould.
3. Couch roll.
4. Doctor board.
5. Shaft through which cylinder is driven.

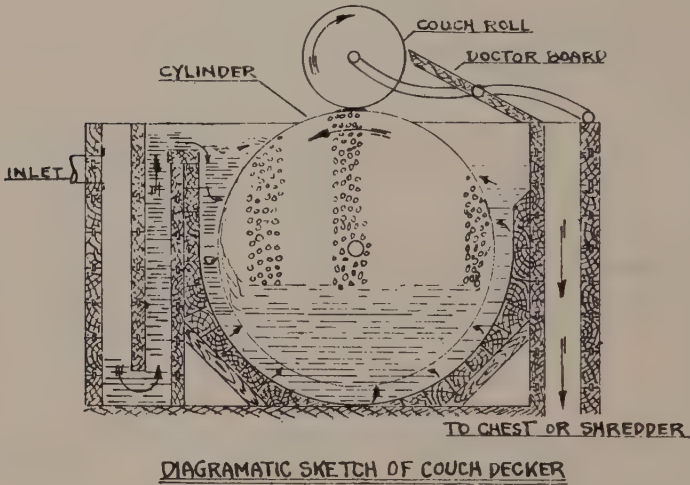


Fig. 74

1. The vat is ordinarily built of tongue and groove wood of approximately three inches in thickness, although metal is also used to quite an extent. The length and width of the vat is largely determined by the space available and the amount of pulp to be deckered per twenty-four hours.

2. The diameter and length of the cylinder mould is determined by the size of the vat. The cylinder must be solidly built and reinforced wherever necessary. It is formed over a number of spiders supported by a shaft. Rods are placed across the spiders and run the full length of the cylinder. These rods are notched to receive a 10 or 12 gauge winding wire which is wound around the cylinder in a continuous strand. On top of this winding is placed a 14 mesh backing wire and on top of that a 30 to 65 mesh facing wire, depending upon the grades of pulp to be deckered and the efficiency of mill operations. Use is frequently made of what is known as "Corduoy Weave" or "Dutch Weave" wire, which is a combination weave of 12 x 64 mesh in the same wire and takes the place of the backing and facing wires.

3. The couch roll is frequently built of pine or cedar strips, bolted to

cast iron spiders which are securely fastened to a shaft. The wood surface is then covered with some soft and yielding material, such as rubber or a woolen felt. The felt may be wound around the roll in the form of a ribbon or a sheet until the desired resilience is obtained. The couch roll is connected to the vat in such a way that the roll may be instantly elevated from the cylinder and remain in the elevated position supported by the couch arms.

4. The doctor board, of hard wood or rubber, is generally attached to the couch roll arms and is otherwise supported as required to make it sufficiently stable. The board is adjustable in any direction so that it may be pressed against the couch roll at any angle desired to remove the deckered pulp from the roll, ready for discharge into a decker stock chest.

5. Bearing boxes for this type of machine are usually of cast iron lined with babbitt. Packing glands are used when the shaft of the cylinder mould passes through the vat. It is necessary that the design of the machine permit easy removal of the cylinder. The drive arrangement will vary with the make of the decker. It may be gear, chain, or belt driven.

Pneumatic Deckers

The pneumatic deckers receive the accepted pulp from the primary and secondary screens at a very low consistency and their function is to thicken the pulp to an economical pumping consistency. The pulp enters the vat of the decker through an adjustable gate, operated by a hand wheel or lever. A baffle board is placed near the intake to equalize the flow of stock. The fibers in the water are deposited on the surface of a cylinder, due to the water passing through the fine mesh wire cloth covering. This cylinder is partially submerged in the mixture of stock and water, and is divided into radial sections that run the full length of it. The ends of each section are open. This provides an exit for the water that flows through the wire-cloth into the pockets formed by the sections. As the cylinder revolves, the ends of each pocket pass by openings in a duct in which a partial vacuum is maintained. The suction action created in the pocket causes the water to flow through the wire cloth into the pocket, which it leaves by the ends. In this way, a film of stock is formed on the outer surface of the cylinder. As each section of the cylinder reaches the top of its revolution, the ends register with another opening in a duct in which air is maintained under pressure, and which blows the sheet of pulp from the wire cloth to a doctor board, from which it is then washed into a chest. The consistency of the pulp leaving the doctor is approximately 3%.

The consistency of the pulp coming to the deckers should be uniformly maintained. In operating a supply to the decker at 0.50% consistency, the standard decker has an approximate capacity of 24 tons per twenty-four hours of operation. If the supply should be thinned to 0.45% consistency,

or reduced 10%, the capacity is reduced to an approximate production of 22 tons per twenty-four hours, or about 92% of the 24 ton production.

The vacuum and pressure on these deckers is furnished by a blower pump, the intake giving the suction for vacuum and the discharge the force to blow the pulp from the cylinder.

These deckers have a high capacity on chemical pulps for the floor space they occupy.

Couchless Decker (The A. D. Wood Machine)

The Wood machine cylinder mould is constructed of heavy iron or bronze spiders spaced at 3 or 4 foot centers instead of the usual light spiders only $4\frac{1}{2}$ " apart. In place of many light rods closely spaced and resting in notches at the circumference of the spiders, 24 yellow pine inclined staves, $1\frac{1}{4}$ " thick by 6" wide, are firmly bolted to integral vanes cast in the spiders. This gives a space of approximately 6 inches between the outer edges of the staves and these edges form a perfectly stiff and rigid foundation for the backing wire. Backing wire is of copper, with individual

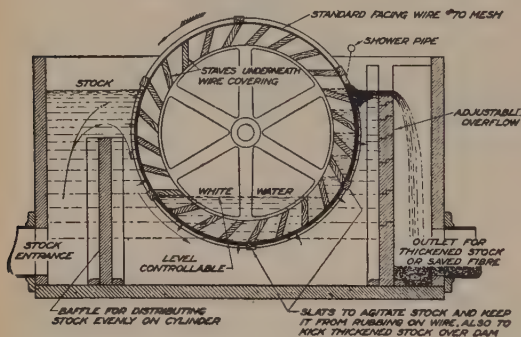


Fig. 75.
Couchless Decker

strands $\frac{1}{16}$ " or more in diameter and having 3 or 4 meshes to the inch, rather than the usual and comparatively delicate 14 mesh, and the use of troublesome winding wire is therefore unnecessary. This greatly increases the available net area of a given cylinder and gives ample support to the facing under the light pressure to which it is subjected, permitting a large and uninterrupted flow with decrease in the tendency of slime to accumulate. The backing wire is securely fastened down by means of copper staples driven into the staves and the facing is then stretched on and the joint soldered directly over a stave. One of six yellow pine slats, 2" wide by 1" thick, is placed over the full length of this joint and firmly screwed to the stave, clamping both wires; and the other slats are similarly fastened at equal intervals around the face. These also serve as agitators to prevent settling in the vat and to elevate the thickened stock, kicking it over the discharge dam and relieving the facing wire of this work.

While the inclined staves discussed above are in a large part responsible for the simplicity of construction of the Wood cylinder, their more important function is the bucket action which raises a small quantity of the waste water and causes it to flush the wires from the inside outwards, thus cleaning the entire face once every revolution, automatically and with minimum power, constantly keeping the meshes open and permitting no decrease in capacity such as commonly results from gradual plugging with fiber, slime, etc. This backwash also removes the pulp sheet from the wire, assisted by the shower. Fig. 75 shows the method of operation clearly.

Some experimenting has been done towards increased production on deckers by speeding up the travel of the face of the decker. Just how far one can go in speeding up has not yet been determined. Experiments at West Linn and Camas have shown increases in production up to 33% by increasing the speed. The mesh of the facing wires in most mills is governed by the mesh of the wires used on the paper machines, due to the fact that old wires from paper machines are used to cover the deckers. The use of 40 mesh wire instead of the 60 and 65 mesh now used would no doubt give an increase in capacity of the deckers with little loss of fiber. Due to the fact that a fiber mat is quickly formed on the facing wire, and as there is no other action than the static head, the fiber loss is no greater with the 40 mesh wire than with the finer mesh wire.

Differences in freeness of the stock give differences in the amount of stock deckered. This freeness figure should be considered when comparing the operation of deckers in different mills. One of the features that should be watched very closely in news mills when deckering stock is the amount of pulp that leaks from the decker into the white water. This extra stock that goes back to the white water, if in sufficient quantities, builds up an additional load on the screens. When it is considered that 50,000 gallons of water are required to carry one ton of pulp through the screen, it may readily be seen that by raising the ratio of stock from about 25 pounds per 1000 gallons of water (which is about normal) to 30 pounds, there is an increase of about 20% in the amount of stock that is being carried through the screens and a similar reduction in screen capacity.

Wet Machines

Wet machines, often called wet presses, are used in producing pulp for shipment or storage. These machines will remove water from the screened pulp and form the fibers into thick sheets which can be folded for easy handling. A folded sheet of pulp, commonly termed a lap, may contain from 30-45% by weight of air-dry fiber, depending upon the machine used in the operation.

The same general principle applies to all wet machines. Their operation is somewhat similar to that of a decker. The main purpose of both is to deliver a thickened pulp.

The essential parts of a wet machine are:

1. Vat.
2. Cylinder.
3. Woolen felt.
4. Couch roll.
5. Guide, Stretch, and Carrying rolls.
6. Press rolls.

In operation, the cylinder, covered with a fine mesh wire cloth (top 60 mesh, bottom 14 mesh), revolves in a vat of fiber and water. The consistency of the pulp entering the vat varies with the efficiency of the screening operation but should be kept uniform at all times. The layer of pulp, which is collected by the revolving cylinder, is couched to an endless woolen felt by pressure. This couching effect cannot be accomplished if the felt is dry; therefore, the felt must be wet when it contacts with the cylinder. The endless felt conveys the thin layer of fibers to the pressure rolls. At this point, while the felt passes between the top and the bottom press rolls, another couch effect takes place.

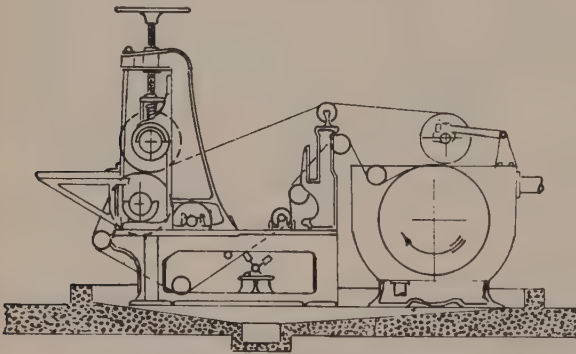


Fig. 76

ONE PRESS WET MACHINE

The pulp adheres to the top press roll and follows it around forming a thick layer of pulp upon it. When the layer is of a desired thickness, an operator skins the pulp covering from the roll, folds the lap three ways and piles it on a skid for storage or for shipment.

After conveying the pulp to the press rolls, and before it again comes in contact with pulp, the endless felt is washed. In this washing operation, fresh water is used. A shower pipe, placed before a whipper, soaks the felt

with water. The felt then comes in contact with the whipper which loosens any embedded pulp that might be in the felt and keeps it in a condition so that water will drain through it readily. The whipper can be so adjusted as to vary the degree of beating. The water that drains through the wire covering of the revolving cylinder is returned to the system as make-up.

It is desired that all pulp produced at Camas be deckered and used in slush form. This operation eliminates the added expense of operating wet machines and that of storing pulp. However, pulp is lapped for the following reasons:

- Transportation.
- Storage purposes.
- Determination of yield.
- Pulp mill overproduction.
- Special grades.
- Special purposes.

At times it is more economical to lap the excess pulp produced by the pulp mill than to stand the added expense of shutting down and starting up that unit of production.

CHAPTER XI

BEATING AND REFINING

By E. WEBBERLEY

PART I—BEATING

History

Up until the eighteenth century, papermaking fibers, mostly from rags, were beaten by hand. Stamping mills, operated by waterwheels and consisting of heavy wooden stampers often equipped with iron teeth, were later developed. The biggest advance was made in Holland in 1750, by invention of the so-called Hollander, identical in principle with the beaters of today.

Admittedly, then, there have not been any radical changes in beater design in 190 years. Certainly, improvements in stock refining have not kept pace with the revolutionary changes in paper machine design and operation. Many improvements have been made to produce faster circulation, higher capacity, lower power requirements, easier operation, longer life, better materials of construction and lower maintenance cost, but the principle of operation has remained unchanged.

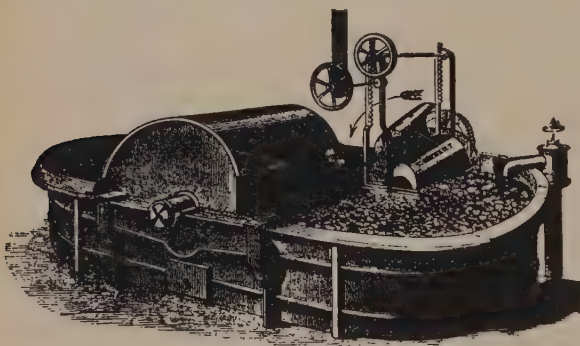


Fig. 77
Beating Engine
65 Years Ago

The first beater rolls were made from logs, grooved to receive metal bars. Being light in weight, these rolls rode on the stock of their own weight. The rag stock then used required frequent stirring by hand to assist circulation.

The next development was the introduction of iron rolls of more or less standard dimensions. At first only one end could be raised and lowered, but later double "lighters" were used to adjust the height of both ends of the roll. The weight and size of the rolls were gradually increased to raise

their beating capacity, with the result that accurate means of setting the roll became essential to prevent undue crushing and damaging of fiber. Later developments resulted from studies of backfall height and shape, bar sizes and shapes, bedplate construction, quick dumping arrangements, and other features of design. Beaters have been designed with more than one roll, and with several bedplates spaced around the lower periphery of the roll.

In the last decade, many new types of refining equipment have been developed, most of them based on the principle of continuous treatment as opposed to batch treatment in beaters. While most of these are excellent in design and operation, experience by and large has shown that for the most part they operate to best advantage on certain types of stock only. For flexibility in hydrating all types of stock, from blotter to glassine, the beater is still the most reliable type of equipment.

Some new methods of hydrating by hydraulic impact and by high frequency vibration are being developed, but as yet these have failed to yield commercial capacity and are still in the experimental stage.

Beater Construction

There are 48 Jones beaters of the Hollander type at Camas, including five beaters used exclusively for repulping broke. These beaters vary in capacity from 800 to 2200 pounds air dry basis.

Fig. 78 shows the principal parts of the type of beater used at Camas. The tubs are wooden with concrete bottoms. The backfalls are concrete covered with metal. Each beater is equipped with a doctor to prevent too much stock being carried completely around with the roll, which would reduce circulation and capacity.

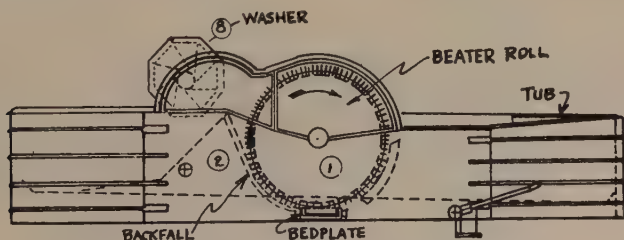


Fig. 78 Diagram Showing Principal Parts of a Beater

In the center of the beater is the midfeather around which the stock circulates. The floor is made as smooth and streamlined as possible and slopes from the top of the backfall around to the roll intake.

Dams are placed ahead of the roll so as to increase the velocity of stock entering the beating area, and since the stock hits the roll at more nearly

roll speed, the braking effect of the stock pickup is minimized.

Bedplates

As shown by diagram in Fig. 79, there are two types of bedplates.

1. Stone bedplates—granite is used at Camas, lava and other stones are often used elsewhere, as in glassine mills.
2. Steel bedplates—consisting of steel bars of different size, shape and arrangement securely clamped between wooden spacers.

Steel bedplates give more cutting action and less bruising of fibers than stone, depending on the width of the bars. The narrower the bars, the greater the cutting action.

For beating kraft, a combination of granite bedplate and corrugated flybars has been found most effective. For beating groundwood and sulphite furnishes, the steel bedplate is usually used.

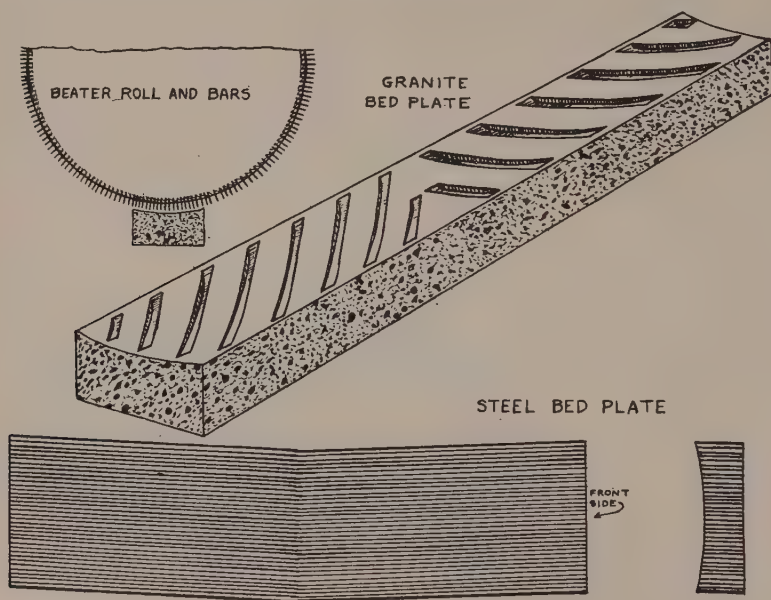


Fig. 79

Note that the bars in the steel bedplate are set at an angle to give a shearing action. The steel used should be softer than the steel in the flybars, and bedplate bars should be a little narrower so that most of the wear is on the bedplate, since the bedplate is easier to repair and replace than flybars.

Flybars

Fig. 80 shows some of the various types of flybars used. The thickness of the bars can be varied according to the relative cutting and brushing action desired.

Corrugated bars have about 15% more beating surface and some 50% greater strength than straight bars, also have a shearing rather than chopping action.

Staggered bars, as shown, have segments cut out of the cutting edge. These segments are staggered, that is, cut in different positions in adjacent

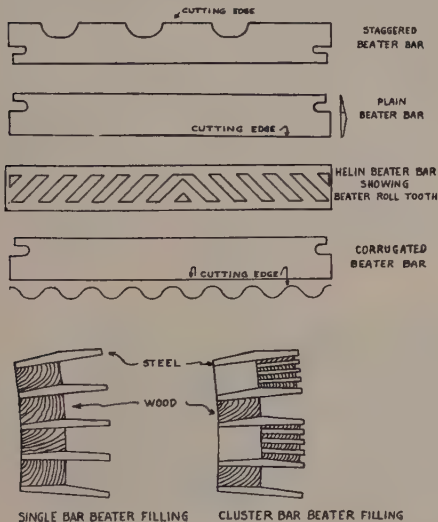


Fig. 80
Types of Flybars



Fig. 81 Method of Locking Flybars in the Bandless Roll
—Courtesy Dilts Machine Works, Inc.

bars. This type of bar has proven very successful for repulping broke and slushing lap and sheet pulp. Tests have shown that staggered bars handle broke in 60% less time than straight bars and circulate 30% faster.

Five beaters at Camas are equipped with stainless steel bars. Ordinary steel bars corrode in contact with alum solutions allowing dissolved iron and bits of scale to affect the color and cleanliness of the furnish.

Fig. 80 shows slots cut in the ends of the bars. These fit the band which holds the bars in place on the roll. Wedge-shaped wooden segments are driven in between the bars and, when swollen with water, hold the bars firmly in place. The single type of filling is used at Camas, but the cluster filling, also shown, is much used in other mills.

This type of construction is known as the banded roll. It is open to the objection that the bands are liable to break or come loose releasing the bars which might cause severe damage or injury. An improved type of roll known as the bandless roll, illustrated in Figs. 81 and 82 has been developed wherein the bars are individually held in place by specially designed wedge blocks. This type of construction also greatly facilitates replacement of bent or broken flybars.

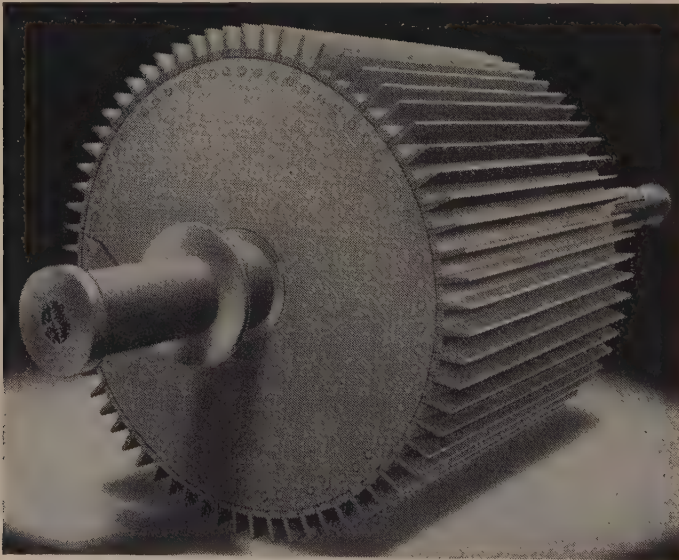


Fig. 82 Bandless Beater Roll

—*Courtesy Dilts Machine Works, Inc.*

The beater roll and spindle together in a 2000-pound beater weigh about $7\frac{1}{2}$ tons and are driven by a 100 H.P. motor.

Special manganese and chrome nickel flybar steels have been developed to resist impact and wear slowly yet retain the cutting edge as the bar wears down.

When a new bedplate or flybars are installed, they must be ground in so as to make good contact across their full width. This is accomplished by grinding the roll and bedplate together in water and sand, some 24 hours usually being required to do a good job. When a bedplate is worn down, it is raised and about $\frac{3}{8}$ " of wood cut out from between the bars to again expose a new wearing area.

Beater Washers

The washer is an octagonal shaped cylinder, as shown in Fig. 78. When lowered into the stock, water passes through the wire covering and is dipped up by the pockets inside the cylinder and discharged through an axial port. The washer is driven by a motor or from the beater roll shaft. Only fifteen minutes are required to reduce slush stock at about 3.5% consistency to a beating consistency of 5.5% to 6.0%.

Operation of Beaters

When brought down to beating consistency, the roll is lowered to brush the bedplate. Roll setting is controlled by power readings on the drive motor and by frequent freeness tests. Roll adjustments are made accurately to 1/100". On some beaters, rolls are raised or lowered with hydraulic mechanism, on others by means of levers known as "lighter" bars. On all beaters, the final adjustment is made with a hand wheel and worm gear. Only qualified beater engineers are allowed to make these adjustments.

Careful records are kept of freeness, consistency, pH, temperature, beating time and pulp quality. These tests and records are made by chemists on each tour. Hand sheets are made for color matches before dropping the beaters.

The surface speed of the roll is adjusted to give the maximum beating effect consistent with power requirements. Speeding up the roll beyond this point accelerates the beating rate but power demands are out of proportion to the results obtained. For example, doubling the roll speed increases power consumption four times. Some 60% of the power consumed in a beater is used in circulating the stock.

Too low consistency of stock in the beater reduces its capacity and cuts down the beating rate. Too high a consistency impedes circulation, and beyond a certain point, circulation stops altogether.

Some of the variables affecting hydrating efficiency of a beater are as follows:

1. Contact inches.
2. Clearance between flybars and bedplate.
3. Pressure.
4. Consistency.
5. Rate of circulation.
6. Arrangement and size of bars.
7. Angle of shear.
8. Materials of construction.
9. Temperature.
10. pH.

Contact inches, or impact inches per minute, is one variable that can be readily calculated for purposes of comparison. It is calculated as follows:

$$\text{Contact Inches/Min.} = \text{R.P.M. of roll} \times \text{No. of bars in roll} \times \text{No. of bars in bedplate} \times \text{effective length of bars in contact.}$$

The refining capacity of jordans can be calculated in a similar manner except that provision must be made for taper and a greater number of bars at the larger end of the cone.

Continuous Beating

Recently at the Port Townsend plant of National Paper Products Company tests were made by arranging beaters in series in units of four. This involved redesign of the backfall and installation of a screw conveyor to carry the stock from one beater to the next. Their experience was that this system increased strength with a lower power demand. Capacity of the system was speeded up by eliminating most of the filling dumping and washing-to-consistency time. This improvement also reduced the power load on the jordans.

A similar system was installed at Camas. Flow of stock to the first beater is automatically adjusted by a float operated valve control. In this beater the washer is kept operating continually. At the back of each beater is a steel plate between doctor and backfall that diverts the stock to a conveyor running the full length of the beaters. The discharge to the conveyor is regulated so that each beater is processing stock at the same rate.

This system combines the advantages of continuous beating with the flexibility of beaters.

PART II—JORDANS

The Jordan is the most common type of refining equipment and is named after its inventor.

Construction and Operation

The machine is conical in shape, consisting of a shell in which rotates a plug machined carefully to an exact fit. Both shell and plug are equipped with bars of suitable size and arrangement. A typical installation is shown in Fig. 84. The stock enters at the small end and is discharged at the large end.

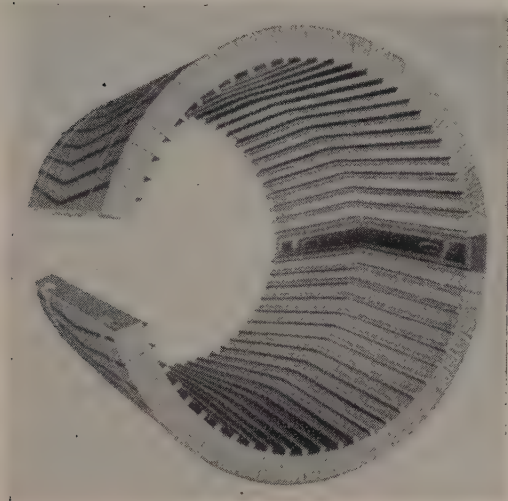


Fig. 83
Spiral Type
Jordan Filling

The drive is usually a direct connected motor with a slip coupling to permit adjustment of the plug in or out of the shell in order to vary the refining action. In some types of jordans the shell is moved which seems to be a more logical setup but has not been generally adopted.

Jordans have a much higher contact inches figure than beaters, about 500,000 per minute, as compared to about 150,000 per minute. This higher capacity will nearly offset their higher power requirements.

When bronze tackle was first used, it was chosen primarily to combat corrosion, but it was soon found that bronze bars produced a much different cutting action than steel. Steel bars tend to round over on the edges producing a brushing action, while bronze bars remain sharp on the leading edge, and have more of a cutting action. Monel metal bars (an alloy of copper and nickel) have an intermediate action. Steel bars tend to "work harden" on the surface by impact.

The action of a jordan depends largely on the size of the bars as well as the metal used. Fine tackle, that is, bars about $\frac{1}{8}$ " thick, produces a cutting action such as required for absorbent papers. Wider bars produce

more of a bruising or brushing action as used for greaseproof and similar non-absorbent papers.



Fig. 84 Jordan

—*Courtesy Shartle Bros. Machine Co.*

Jordans, however, are primarily designed for cutting action and should not be overloaded by doing the work of hydration best accomplished in the beater. Jordans can be flexibly controlled to operate more or less as a correcting factor for variations in beating and allow the machine tender to quickly adjust formation, densometer, oil absorption, Mullen and other sheet properties dependent largely on refining action.

The modern jordans in the Camas mill run at speeds up to 400 R.P.M. in contrast to 150 R.P.M. in earlier types of equipment. Other refining machines at Camas run at speeds as high as 1200 R.P.M.

Careful consistency regulation is important for uniform jordanning and for this reason jordans are supplied directly from the Warner equalizers. An increase in consistency may change the action of jordans from cutting to brushing and increases power consumption. This action can also be regulated by adjustment of the choke valve on the discharge line.

The efficiency of jordans may be increased by using close spaced bars in shell and plug filling.

As in the case of beaters, much of the power used is required to pump the stock through the machine.

CHAPTER XII

COLORING, SIZING AND LOADING

By F. W. FLYNN

PART I—COLORING

Development of Aniline Dyes

William Henry Perkins, a chemistry student in the Royal College of London, accidentally discovered "Mauve," first of the aniline dyes, while trying to isolate phenanthrene from coal-tar to make artificial quinine. Since Perkins' discovery, chemists have produced synthetically hundreds of colors of various characteristics and in a wide range of shades.

Colors, or "dyes", as we know them today, are complicated chemical compounds. The products obtained from coal-tar produce the bases from which nearly all the paper dyes are produced. These products are obtained by distillation with acids, alcohols, and other chemicals. There are, however, many steps between the coal-tar products and the final dyes ready for use in the beaters.

There are substances derived from these coal-tar materials which, in turn, are used for making dyes, explosives, perfumes, etc. The substances used for dyes are called "dye intermediates," of which some 500 are known. A few of the most important ones are: aniline, chloro-benzene, paradichlorobenzene, dimethyl aniline, nitrobenzene, phenol and phthalic acid.

By combining these dye intermediates with acids, either organic, inorganic or both, and subjecting them to temperature and pressure, the various dyes, depending on the intermediates and acid, are produced. The particular combination of chemicals chosen produces acid, basic, direct, sulphur, lake or vat colors.

The colors of particular interest to the papermaker are Acid, Basic and Direct colors. In certain grades of paper pigments are of importance, such as sap brown which is a product of fossilized vegetation. This pigment is soluble in water but becomes insoluble immediately upon contact with alum. However, by far the greatest number of colors used in papermaking are aniline dyes.

Soluble American Blue is another example of a pigment and is made by the combination of iron and cyanide. It is also soluble in hot water and is precipitated upon contact with alum.

There are also insoluble pigments such as Ochres that are similar to dyes but which are held mechanically in the fibre structure of the sheet.

Basic Dyes

By virtue of their high coloring, or tinctorial, power, basic dyes are the most economical for most shades of unbleached sulphite, kraft bag, wrapping, tissues and news. However, they are seldom used in high grade papers, except in small quantities to brighten the shade.

Basic dyes are on the market in the form of salts, such as the hydrochloride, the color portion of the salt being basic, and for this reason they are so called.

The main objection to basic dyes is their lack of fastness to light. In fact, with a few hours exposure to direct sunlight, the paper returns to almost the color of the stock before it was dyed. Another objection to some of the basic dyes is that highly colored fibers appear in the finished paper, due to the dye having greater affinity for certain fibers, and these fibers make the paper appear mottled. This last objection can usually be overcome, however, by proper care when this class of colors is being used.

Alum is not needed to set the color on the fibers on light or medium shades, but is required on the deep shades.

Solutions of the basic dyes may be boiled, with the exception of auramine and chrysoidine, which lose strength on being heated over 160° F.

Acid Dyes

These coloring materials have, in the course of their manufacture, been treated with sulphuric acid, becoming acids themselves, called sulphonic acids, which are then neutralized with an alkali to form a salt. Since the acid portion of the salt is the color portion, they are called acid dyes.

This group has a range of bright colors with good fastness to light and with better solubility than the basic dyes. However, they have less coloring power than the basic dyes, since they have less affinity for vegetable fibers. Acid dyes are used only for sized paper, the dye being added to the stock first and allowed to become incorporated with the stock. The size and alum are added last in order to fix the dyestuff on the fibers.

It is best to add these dyes to the beaters in solution. Solutions of acid and basic dyes should not be mixed, as a color lake is precipitated out. However, the stock can first be dyed with an acid dye, and then topped with a basic dye with satisfactory results. Acid dyes are also used extensively for calender staining or surface coloring.

Direct or Substantive Colors

These are salts or color acids which do not require acid (alum) to develop their tinctorial power. They can be fixed completely on the fibers, and therefore give no trouble in regard to colored backwater from the machine.

These colors are used particularly for the manufacture of blotting and copying papers and for mottled fibers. Direct colors possess good affinity for practically all the various materials used for paper manufacture, and in conjunction with suitable acid colors are very useful for level dyeings on mixed pulps.

The coloring process with the direct colors is very simple, the color solution being merely added to the beater and the stock allowed to run until the dye is uniformly mixed with the pulp. For medium or heavy shades it is advantageous to add 5% to 10% common salt, and to heat the pulp to 105° to 120° F. As a class, direct dyes produce faster to light shades than do either the basic or acid dyes.

Acid and direct dyes may be mixed and used together for some purposes, but neither acid nor direct colors should be mixed with basic colors, either in the dry state or in solution. If necessary to use basic colors with either acid or direct colors the solutions should be added to the stock separately.

It has been observed in using basic dyes in tissue grades that more of this dye is required in the summer time than in the winter, probably due to the fact that the Columbia River water used in the summer time is harder than the lake water used in the winter, the basic dyes being sensitive to hard water.

During the last few years, a new series of dyes has appeared on the market, a series that has remarkable fastness to light and brilliancy. These are the organic pigments, an example of which is Solar Blue RX, which is used on the best bleached sulphite grades for tinting white shades. These dyes are made by precipitating special blue or violet aniline dyes with tungstic acid to form lakes. They are added to the beaters as soon as the stock is furnished, before the size and alum are added. Hydration helps their retention and alum is necessary to fix the dyestuff on to the stock.

Effect of Fiber Type

Several factors enter into the coloring of paper. Unbleached sulphite, bleached sulphite, kraft, bleached kraft, and groundwood pulps all act differently toward dyestuffs. Unbleached sulphite takes up and holds certain dyestuffs easily, because the sulphite process leaves lignin and other residues in the stock which have a natural affinity for dyestuffs, especially for the basic dyes which are mostly used on this stock.

Bleached sulphite is not easily colored, since the purifying action of the bleach liquor largely removes these lignin residues. Care must therefore be used in selecting dyes for bleached sulphite.

Kraft is reddish-brown in color and requires considerable dye to make much impression on it; however, it takes up the dyestuff readily.

Bleached kraft acts like bleached sulphite and does not adapt itself readily to being colored, particularly in deeper shades.

Groundwood does not take up dyestuffs readily, because the lignin and impurities present are not in such an active state as in unbleached sulphite, and it is difficult to color or dye groundwood with most dyestuffs. Substantially, more dye is required to reach a given shade with groundwood than is needed for the same shade on unbleached sulphite.

Rosin size helps to fix the majority of dyestuffs on the fibers. The dye should be added to the beater and allowed to mix with the stock before the size and alum are added. With acid colors an excess of alum is required to set the color.

Beating affects some of the dyestuffs, particularly on loaded papers, and since there is always a loss of filler in the backwater, there is an accompanying loss of color. For this reason it is best to allow the stock to absorb as much color as possible before the filler is added. Increase in efficiency of suction couches and suction presses has directed more attention to control of coloring to minimize two sided effects.

The finish and moisture content of the paper also affect the shade. In a high finished grade, or in a moist sheet, the shade appears deeper.

Retention of Dyes

An important phase of color control is calculating the cost of aniline formulas from laboratory matches. Consideration must be given to retention of the dyes on the fiber in the beaters in order to arrive at the true overall cost.

Although, as a general rule, lignified fibers fix dyestuffs more readily than bleached fibers, this is not always so. Is it true with basic dyes, but certain acid and direct dyes, for example, DuPont Crocein FL and Pontamine Fast Red 8BL, are actually retained better by more highly purified pulps.

The retention value of dyestuffs seems to depend on their molecular arrangement. Basic acid and direct dyes cannot be classified as a group as members of each group vary widely among themselves, as shown by the following table, quoted from a research thesis prepared by Mr. W. D. Harrison, of Riegel Paper Corporation.

RETENTION OF VARIOUS DYES ON UNBLEACHED SULPHITE

BASIC DYES		Per Cent Retention
DuPont Victoria Green SC with triphenylmethane grouping.....		95.3
DuPont Rhodamine B with xanthene grouping.....		85.4
DuPont Auramine Conc. with ketonamine grouping.....		94.8
DuPont Methylene Blue ZX with thiazine grouping.....		96.3
DuPont Basic Brown BR with disazo grouping from diamines.....		53.8
DuPont Safranine T Extra with azine grouping.....		94.8
DuPont Methyl Violet NE with triphenylmethane grouping.....		91.8
ACID DYES		
DuPont Brilliant Crocein FL with monoazo grouping.....		41.8
DuPont Anthraquinone Blue B with anthraquinone acid grouping.....		5.6
DuPont Nigrosine WSB Powder with very complex unknown structure.....		15.9
DuPont Quinoline Yellow Conc. with quinoline grouping.....		11.7
DuPont Orange II Conc. with monazo grouping.....		14.2
Pontacyl Violet 4SB with triphenylmethane grouping.....		36.1
DIRECT DYES		
Pontamine Fast Red 8 BL with disazo grouping.....		49.1
DuPont Purpwine 4 B Conc. with disazo grouping from diamines.....		76.1
Pontamine Black E with trisazo grouping.....		55.7
DuPont Brilliant Paper Yellow Conc. with mono-stilbene grouping.....		39.6
Pontamine Fast Scarlet 4BS with disazo grouping.....		30.6
Pontamine Yellow SX P with di-stilbene grouping.....		25.9
Pontamine Fast Yellow>NNL with triazole grouping.....		58.3

Mr. Harrison summarizes the retention characteristics of dyestuffs in a very comprehensive manner as follows:

"At very low dye concentrations, relatively large percentage of dyes are held on the fiber. As the dye concentration is increased, the amount held on the fiber at the end of a given time also increases, but at a much less rapid rate than would correspond to a linear relationship.

"Basic dyestuffs are attracted strongly by lignified fibers and give dye retentions above 85%. When bleached, however, the fibers attract these dyestuffs to a lesser extent; it can be said that, in general, the fiber is the most important variable in so far as basic dyes are concerned. The temperature, time, and hydrogen ion concentration of the reaction mixture have very little effect on the retention of this class of dyestuff, while increased consistency and lower freeness cause considerable increases in retention.

"With acid dyestuffs, the fiber variable is not so important for dye retention. Relatively small changes are obtained when the fiber is changed, the purer pulps giving higher retentions. The temperature of the reaction apparently has very little effect on the retention of acid dyes. Hydrogen ion concentration affects the retention probably more than any other variable, giving higher results at a pH of less than five. With high con-

sistency and low freeness, increases in retention are noticed, while increases in time of reaction have only small effects.

"The retention of direct dyestuffs is somewhat affected by the type of pulp being dyed. Bleached and refined pulps produce slightly higher retentions than the highly lignified pulps. The hydrogen ion concentration and the temperature of the reaction mixture have very little effect on the retention, while increased time of reaction, increased consistency, and decreased freeness produce considerable increases in the retention of this class of dyestuff."

Color Combinations

To obtain the various shades of finished paper for the many grades, and to take care of variations in the shade of the stock received in the beater room, the various colors are mixed in the beaters to make color matches for the standard samples.

Combinations of colors are shown in Fig. 85.

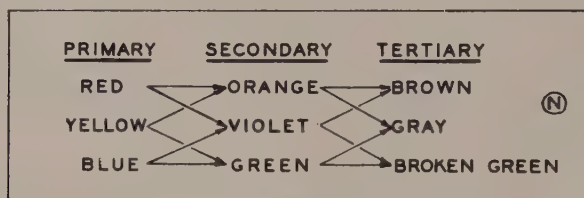


Fig. 85 Color Combinations

By mixing the three primary colors, red, yellow and blue, thousands of different shades can be made. The primary colors may be used alone or blended to make other shades, the so-called secondary shades, orange, green and violet, which again may be blended to produce the tertiary colors. Tertiary colors are occasionally used in combination with primary colors. For example, in coloring orange citrus, chrysoidine R, a reddish-brown tertiary color, is blended with safranine, a red primary color.

In mixing colors, care must be used to select dyestuffs to produce the desired shade with the most effective combination. For example, in mixing a violet with blue and red, if a red that is more of a scarlet with a touch of yellow is used with a blue that has a greenish tinge, a grayish dull violet will result instead of a full violet, since all three primary colors are present to a degree. To make a bright green there should be no red present, as there would in using an orange-yellow with blue, since a sage green would result instead of an emerald green. In making an orange color, when a pure

shade of orange is desired, the red and yellow primary colors must not have a bluish tinge, or a muddy shade will result, due to the presence of a third primary color, blue which dulls the shade down. Of course, it is possible to purchase excellent orange dyes that are not mixtures, but in coloring paper, the underlying essential principles must not be overlooked, since it is necessary to constantly shade the stock in the beaters to meet the stock and machine conditions in order to hold the color steady on the paper machines.

When a new shade is to be matched, the first consideration is to determine the purpose for which the paper is to be used, and select the dyes accordingly. For instance, in the dyeing of wrapping paper, it would be proper to use basic dyes, which have relatively poor fastness to light, but which have great tinctorial power and relatively low cost. On cover paper, subject to more exposure, fast to light dyes, either acid or direct, should be used. For soap wrap, dyes must be selected that are fast to both light and alkali, to avoid effect of the alkali in the soap in fading or changing the color of the sheet.

Unbleached pulp fades and discolors when exposed to sunlight or is subject to acids or alkalies so it is usually not necessary to use dyestuffs more permanent than the fiber itself. In some cases, where deep permanent colors are desired the fading effect of the base stock can be made unnoticeable by the application of good fast to light dyes. Tire wraps made at Camas are good examples of such heavily colored unbleached papers.

The cost of tinting a ton of paper ranges from a few cents per ton on light shades up to many dollars per ton on shades of certain grades. In a specialty mill such as Camas, it is exceedingly important to select economical dyes and combinations of dyes which will make it possible to obtain uniform shades on the paper machine, yet produce the necessary brilliance, fastness to light, and other requirements of special grades.

General Characteristics

Some properties of the more important papermaking dyes have been summarized by dye manufacturers and from which the following is quoted:

E. I. DuPont de Nemours & Co., Inc., reports as follows:

"The control of pH in the beater dyeing of paper is becoming an increasingly important factor as more mill operators and technical men realize that the full development of strength and shade of a dyestuff is largely a function of the pH at which it is applied. Inasmuch as the optimum dyeing conditions vary widely over the range of dyestuffs applicable to paper, it is essential that the characteristics of each dyestuff be fully

appreciated if the best results are to be obtained. It is to this end that the Technical Laboratory has prepared the following table."

The properties of each dyestuff were investigated over the pH range of 4.4 to 7.0 and the control of acidity accomplished by varying the quantity of alum. Two percent of rosin size was used in each case and sufficient alum added to give pH values of 4.4, 4.5, 5.0, 5.5, 6.0, 6.5 and 7.0 after dilution of the stock to $\frac{1}{2}\%$ consistency with neutral water. These values, then, refer to the stock suspension at the headbox of the paper machine. The pH in the beater will generally be lower.

The approximate quantities of alum required are listed below but it should be remembered that these amounts will vary with the alkalinity of the size and with the water used for dilution of the stock. It is also essential to state that if more or less rosin size is used the alum required does not vary in direct proportion. The reason is that alum is a much stronger acid than rosin is an alkali.

Twenty-five pounds of alum are recommended for most colors and it will be noted that only 2 to 3 pounds of this amount are required to neutralize the alkalinity of 20 pounds of rosin size. If, for example, the size were increased to 40 pounds, only 2 to 3 pounds of additional alum would be required to produce any given pH value, and not double the amount.

For 1000 Pounds of Stock	and	20 Pounds of Rosin Size
2- 3 lbs. alum	—	pH 7.0
6- 7 " "	—	pH 6.5
9-10 " "	—	pH 6.0
13-14 " "	—	pH 5.5
18-19 " "	—	pH 5.0
25 " "	—	pH 4.75
40 " "	—	pH 4.5
55 " "	—	pH 4.4

Where possible, we have specified an optimum pH range rather than one value. Notation in the columns for higher and lower pH refer only to pH values above and below the optimum and within the range investigated, i.e., from 4.4 to 7.0.

The fastness properties of each dyestuff are also included in the table. However, it is extremely important that the conditions of these tests be borne in mind as related to the use requirements of the paper. For example, a dyestuff rated "Fair" to alkali may show excellent fastness to dilute alkalies and undergo drastic change with concentrated alkalies. Hence the

degree of fastness desired must be considered in the selection of the dyestuff for a particular purpose.

Fastness to light is a purely relative matter and difficult to evaluate because of its intimate relation to the depth of the dyeing. We have carefully prepared equal strength dyeings of each dyestuff in medium depths and exposed them to the Fadeometer for varying lengths of time. Judgments are based as follows:

		<u>Not Faded in</u>	<u>Appreciably Faded in</u>
P	= Poor	—	Less than $\frac{1}{2}$ hour
F	= Fair	$\frac{1}{2}$ hour	$1\frac{1}{2}$ hours
G	= Good	$1\frac{1}{2}$ hours	3 hours
VG	= Very Good	3 hours	6 hours
Ex.	= Excellent	6 hours	12 hours
Perm.	= Permanent	Not affected after long exposure	

Fastness to acid, alkali and silicate was determined by spotting dyeings with $\frac{1}{2}\%$ sulfuric acid, 1% caustic soda, and 40° Bé. silicate of soda respectively.

Judgments range from "Excellent" for no change in shade or strength to "Poor" where the color is destroyed or a decided change in shade results. It should be stated that the drop of the reagent was permitted to remain on the dyeing until completely evaporated. The excess was not blotted off. This results in a much more drastic test.

Fastness to chlorine was determined by spotting with hypochlorite solutions containing .01% and .15% available chlorine. Judgments range from "Excellent" for no change with either strength solution to "Poor" where the color is destroyed by both solutions.

DYESTUFF	Optimum pH Range	Higher pH	Lower pH	Caustic Soda	Silicate	Acid	Chlorine	Light
DuPont Auramine.....	4.5-6.0	Weaker	Weaker	P	P	P	P	P
Concentrated								
DuPont Quinoline.....	4.5-5.0	Weaker	—	P	G	VG	P	VG
Yellow Conc.								
DuPont Quinoline.....	4.4-6.0	Weaker	—	P-F	G	Ex	P	G
Yellow P Extra Conc.								
Pontamine Fast.....	4.4-6.5	Weaker	—	F-G	VG	P	P	G
Yellow 4GL								
Pontamine Fast.....	4.4-6.0	Weaker	—	VG-Ex	Ex	P	Ex	VG
Yellow NNL								
Pontamine Yellow SXG.....	4.4-5.0	Weaker	—	P-F	G-VG	G-VG	Ex	F
DuPont Brilliant.....	4.4-5.5	Weaker	—	P	P	P	P	VG
Paper Yellow Conc.								
Pontamine Yellow.....	4.4-6.0	Weaker	—	G	VG	P	Ex	G
CH Concentrated								
Pontamine Fast.....	4.4-6.0	Weaker	—	VG	Ex	P-F	Ex	VG
Yellow BBL								
Pontamine Yellow.....	4.4-6.0	Weaker	—	F	VG	G	Ex	F
SXP Concentrated								
Pontamine Yellow SXP.....	4.4-5.5	Weaker	—	P-F	VG	F	Ex	G
DuPont Stilbene.....	4.5-5.5	Weaker	—	P	P	F	VG	F
Yellow G Conc.								
DuPont Metanil.....	4.5-4.7	Weaker	—	P	G	P	P	F
Yellow Conc.								
Pontamine Yellow SXR.....	4.4-6.0	Weaker	—	P-F	VG	F-G	Ex	G
Pontamine Fast.....	4.4-6.0	Weaker	—	P-F	F-G	P	G	G
Orange EGL								
Pontamine Fast.....	4.7-5.5	Weaker	Weaker &	P	P	P	G	VG
Orange MRL			Yellower					
DuPont Chrysoidine GN.....	5.0-5.5	Weaker	Redder	P	P	P	P	P
DuPont Chrysoidine R.....	5.0-5.5	Weaker	Redder	P	P	P	P	P
DuPont Orange II Conc.....	4.4-4.7	Weaker	—	P	P	F	F	G
DuPont Orange RO.....	4.4-4.7	Weaker	—	P	F-G	F-G	P-F	G
Pontamine Fast Orange WS.....	4.5-5.0	Weaker	—	P	G-VG	P	P	G
Pontamine Brown D3GN.....	4.5-5.5	Weaker	—	P	P	P	P	F
Pontamine Brown N3G.....	4.5-6.0	Weaker	—	P	P	P	P	G
Pontamine Fast Brown RKL.....	4.4-5.5	Weaker	—	P	P-F	P	G	G
DuPont Basic Brown GXP.....	4.4-6.0	Weaker	—	P	P	P	P-F	P
DuPont Basic Brown BR.....	4.4-5.5	Weaker	—	P	P	P	P-F	P
Pontamine Brown CR.....	4.4-5.5	Weaker	—	P	P-F	P	P	F
Pontamine Fast.....	4.4-5.0	Weaker	—	G	G	P	P	G
Scarlet 4BS								
DuPont Congo Red.....	5.5-6.0	Bluer &	Weaker &	G	VG	P	P	G
4B Concentrated		Brighter	Duller					
Du Pont Purpurine.....	5.5-6.0	Bluer &	Yellower	G	VG	P	P	G
4B Concentrated		Brighter	& Duller					
DuPont Brilliant Crocein FL.....	4.4-4.7	Weaker	—	P	G-VG	F	P	Ex
DuPont Crocein Scarlet N.....	4.4-4.7	Weaker	—	P	F-G	P	P	VG
Extra								
Pontacyl Fast Red AS.....	4.4-5.5	Weaker	—	P	F-G	P-F	P	F
DuPont Rhodamine 6GDN.....	4.5-6.0	Weaker	—	P	P	P	P	F
Extra								
Pontamine Fast Red 8BL.....	4.4-5.5	Weaker	—	P	P-F	P	F	VG
DuPont Safranin T Extra.....	5.5-6.5	Weaker	Weaker	F	F	P	P	P
Pontacyl Ruby PL Conc.....	4.4-5.5	Weaker	—	P-F	F	P	P	G
Pontamine Red 12B Conc.....	4.4-5.0	Weaker	—	P	P	P	P	G
		& Bluer						
Pontamine Fast Pink EBN.....	4.4-5.0	Weaker	—	P	P	F-G	F	F
DuPont Rhodamine B.....	5.0-5.5	Weaker	Weaker &	P	P	P	P-F	F
			Yellower					
DuPont Fuchsin Conc. Powd.....	4.5-6.5	Weaker	—	P	F	P	P	G
Pontacyl Violet C4B.....	4.4-6.0	Weaker	—	P	P-F	P	P	F
Pontacyl Violet S4B.....	4.4-5.5	Weaker	—	P	P-F	P	P	P
DuPont Methyl Violet NE.....	4.4-6.5	Weaker	—	P	P-F	P	P	P
Pontamine Brilliant Violet B.....	4.4-7.0	—	—	P	F	G-VG	P	G
Pontamine Fast Heliotrope B.....	4.4-7.0	—	—	P	P-F	P	P	G
Pontamine Violet N.....	4.4-6.0	Weaker	—	P	F-G	P-F	P	G
Ponsol Violet RRP Powder.....	4.7-5.5	Weaker	Slightly	G	Ex	VG-Ex	Ex	Perm.
			Weaker					
Halopont Violet N.....	4.4-6.0	Weaker	—	F	G	VG	F	Ex
Halopont Blue GN.....	4.4-6.0	Weaker	—	F	G	VG	F	Ex
Halopont Blue MBXN.....	4.4-6.0	Weaker	—	P-F	F-G	F-G	F	Ex
Ponsol Blue RP Triple Powd.....	4.7-5.5	Weaker	Slightly	G	Ex	VG	Ex	Perm.
			Weaker					

Continued

DYESTUFF	Optimum pH Range	Higher pH	Lower pH	Caustic Soda	Silicate	Acid	Chlorine	Light
Halopont Blue RN.....	4.4-5.5	Weaker	—	P-F	G	F-G	F	Ex
Halopont Brilliant Blue 2 RN.....	4.4-6.0	Weaker	—	P-F	G	P-F	F	Ex
DuPont Methylene Blue ZX.....	6.5	Weaker	Weaker	P	P	P-F	Ex	P
DuPont Paper Blue S.....	4.4-5.0	Weaker	—	P	P	Ex	Ex	Ex
DuPont Anthraquinone.....	5.0-5.5	Weaker	Weaker	P	P	P	P	VG
Blue B								
Pontamine Sky Blue 6BX.....	4.4-6.0	Weaker	—	P	F	VG	P	F
DuPont Victoria Blue BX.....	4.4-6.0	Weaker	—	P	P-F	P-F	P-F	P
DuPont Victoria Pure Blue.....	4.4-5.5	Weaker	—	P-F	F	P	P	P
BO								
Pontamine Fast Blue 4GL.....	4.4-6.0	Weaker	—	F	*P-F	F	P	G
Pontamine Blue BBN.....	4.4-6.0	Weaker	—	P-F	F	G	P	F
Pontamine Deep Blue BH.....	5.0-5.5	Weaker	Trace	F-G	G-VG	G2	P	G
Conc.			Weaker					
Pontamine Fast Blue SFL.....	4.4-6.0	Weaker	Redder & Duller	F	F-G	F	P	VG
Pontamine Fast Blue RRL.....	4.4-5.5	Weaker	—	P	F-G	P-F	P	G
Pontacyl Fast Blue R.....	4.4-5.0	Weaker	—	P	P	P	P	F
DuPont Soluble Blue R.....	4.4-5.5	Weaker	—	P	P	P-F	P	P
DuPont Paper Blue R Conc.....	4.4-6.0	Weaker	—	P	P	P	P	P
DuPont Brilliant Green.....	5.0-5.5	Weaker	Weaker	P	P	P-F	P	P
Crystals								
DuPont Victoria Green.....	4.7-6.0	Weaker	Weaker	P	P	P-F	P	P
Small Crystals								
Pontacyl Green BL Conc.....	4.4-4.7	Weaker	—	P	P	P-F	P	F
Pontamine Green GX.....	4.4-5.5	Weaker	—	P	P	G	P	VG
Pontamine Green BX.....	4.4-5.5	Weaker	—	P	P-F	F-G	P	F
Pontacyl Blue Black SX.....	4.4-5.0	Weaker	—	P	P	F	P	VG
DuPont Nigrosine WSB Powd.....	4.4-5.0	Weaker	—	P	P	F	P	VG
DuPont Nigrosine WSJ Powd.....	4.4-5.0	Weaker	—	P	P	F	P	VG
Pontamine Black E.....	4.4-5.5	Weaker	—	P	P	F	P	G
DuPont Fiber Black N.....	4.4-5.5	Weaker	—	P	P	F	P	G

*Varies in shade from a light blue at 7.0 to a dull violet at 4.4 with no change in strength.

The Heller & Merz Corporation have given us the following pertinent information.

pH AT WHICH DYESTUFFS WORK BEST

Values obtained by varying amount of alum, rosin being held constant.

DYESTUFF	OPTIMUM pH
Auramine 00.....	4.3
Brilliant Fast Yellow G2N Conc.....	4.3
Green MX Conc.....	4.3
Orange Y.....	4.3
Methylene Blue 2B Conc.....	4.9
Chrysoidine Y.....	4.3
Violet 4 BPX Conc.....	4.3
Rhodamine BX Conc.....	4.3
Soluble American Blue.....	4.6
Pheno Fast Yellow 95 Conc.....	4.2
Pheno Yellow 3G.....	4.2
Dark Brown S.....	4.8
Sap Brown Extra.....	4.8
Violet 6 BN.....	4.5

PART II—SIZING

The sizing of paper is a very important item in its manufacture, since it determines the water absorbent or repellent quality of the sheet. It makes the difference between a grade like blotting paper that will not hold the ink on the surface and writing paper on which the ink will dry on the surface without running out or "feathering" into the fibers. It determines the difference between a piece of paper that takes up water readily, as does toweling, and a piece of butcher paper that can be immersed in water for some time without losing a great degree of its strength.

Without sizing, a great many grades of paper would lose their utility value. Paper sizing comprises **glueing** of the fibers together and at the same time putting on a coating of more or less water resistant material, in fact that, is where the term "sizing" originates. It is an old word, which seems to have come from the Latin "assidere," meaning to "set into place." Later, when it first began to be applied to papermaking (this dated back to the early Italian, where the really first likeness to the modern art of papermaking centered after its introduction from China about the twelfth century), the term was "assisa." The practical man left off part of it and called it "sis," and that is how the word "size" or "sizing" developed.

Sizing Materials

Starch, or the starchy extractions of vegetables, was the first sizing material used in the crude writing papers of the early development of the art, followed by animal glue. Modern practice, however, has gone largely over to the use of rosin, which is a hard, glassy substance, a product of the pine tree. Its source in this country is largely the pine forests in the South, where the two grades, wood and gum rosin, are obtained. Gum rosin is a natural exudation of the pitch from the tree itself. The tree is tapped and the rosin, as it runs out, hardens in a gummy lump on the bark.

Wood rosin is obtained from the waste wood and stumps of the pine. The waste and stumps are cut up, chipped and then extracted with boiling water, the main product of this extraction being turpentine, with the rosin as a by-product. Wood rosin, thus extracted mechanically from the chips of the tree, is usually somewhat darker in color than gum rosin and is not as suitable for high-grade rosin sizing because it more or less carries its color to the papers. For lower grade papers it can be used to advantage, but for fine quality papers it is necessary to use a high grade of rosin size made from light colored gum rosins. This is the type used in the Camas mill. Rosin is essentially abietic acid, and being an acid will combine with an alkali and can thus be worked up into a material that is emulsifiable in water and which can then be dispersed readily in the beater furnish.

In making rosin size, the rosin is crushed, then cooked in a strong solution of alkaline soda ash. It requires about 14 to 16 pounds of soda ash by weight to 100 pounds of rosin to produce what is known as "thick" size. This is dispersible in water, whereas the original rosin would not be. In order to make it usable in paper, the thick size is diluted from about 70% dry matter to a solution having about 4% dry matter. Rosin size is really a "soap," as it will produce lather or foam typical of soaps in general. The process of making the rosin into size is one of getting the insoluble rosin into a state so that it can be dispersed in water and thereby mixed with the slush pulp.

Handling of Rosin Size

The Camas mill gets its thick size in tank cars, and goes through the operation first of preparing it into thin size. After about an hour's heating with steam, when the rosin is fluid enough to flow quite readily, an air hose is connected to a valve on the top of the car and the rosin size forced through a pipe into one of four large storage tanks. These tanks, holding about 7,500 gallons each, are used either for thin or for thick size. In making thin size, the size maker lets down into a measuring tank about 1,800 pounds of thick size and heats it with a steam coil until it is very fluid, then blows it through an emulsifier, which is an arrangement whereby steam and water can be admitted simultaneously. The mixture passes through a turbine arrangement which disperses the size uniformly and produces the thin size suitable for measuring directly into the beaters.

Tanks located at the beaters are of such dimensions that the size is measured in inches on a gauge, and are so arranged that one inch measurement on the tank is equivalent to one pound of solid size material.

The circulation of pulp in the beater causes the pulp fibers and sizing solution to be, of course, intimately mixed. The action is merely physical, that is, one of getting the soapy film of rosin solution well coated upon the individual fibers. It is the nature of a soap solution to be able to do this, to be able to get a closer contact to the fiber surface than with a water solution alone. After about a half-hour circulation in the beater, the rosin soap films are fairly well sheathed over the fibers; then comes the procedure of again precipitating the rosin as a sticky, adhering gummy substance out of the soap film by alum. Alum when dissolved in water makes an acid solution, and when enough has been added to over-balance the alkaline condition of the soap solution of rosin, the rosin comes out as an insoluble gum on the fibers. It does not come out as the original rosin, but this time as a mixture of free rosin and a complex combination of alumina from the alum and rosin. The proportion which finally adheres to

the fibers through the following processes of putting the stock over the paper machine is about 50% of that put in. So, if 3% of dry rosin size is used in the beaters, about 1½% is retained in the finished paper.

It requires about one pound of alum theoretically to precipitate in the beater one pound of dry size content of the thin size solution. However, in actual practice in the beater room, more alum than this is used. It must be remembered that all mill water is more or less "hard," containing dissolved calcium salts, which have an alum "demand" of their own, that is, a certain amount of the required alum will be expended first in chemical action upon this water hardness instead of in reaction with the rosin. Therefore, alum usage amounts to about 1½ pounds per pound of dry size, decreasing in proportion to somewhat less on papers where sizing is increased. Also, alum excesses are required to set certain dyestuffs, as described earlier in this chapter.

The paper industry uses about one-third of the entire alum consumption of the United States. In 1935 some 117,000 tons of this chemical were used by paper mills.

Degree of Sizing

There is a very definite limit to the good effects on the paper that further increase in sizing will accomplish. It does not increase the water resistant effects upon the sheet to continue to add size in excess of about 4% of the weight of the air-dry pulp content of the slush pulp in the beaters, as it seems that the fibers will carry about so much coating and any in excess goes mainly to waste in the paper machine filtrate water.

There are four different degrees of sizing effects sought in making Camas grades:

1. No sizing at all, or "water-leaf," like a blotter. Such papers as citrus wrap grades, toilet tissues and tissues in general.
2. A minimum amount of sizing added. Such papers as toweling, which wants to be very rapidly water-absorbent, yet must have a little slowing up of water absorption to make it have a better utility in its washroom use.
3. A medium amount of sizing; bag paper is the best example for this case. Enough water resistance to hold the paste used in making the bags from soaking in too fast, so that a bond between the fibers of the folded sheet contacts can dry, yet not so water resistant that the paste lies in top of the paper producing a weak bond.
4. Hard sizing, such as in butcher paper, which must come into the rigorous use of contact with meat juices for hours without losing too much strength, or soaking through.

The technical department has a method of scientifically measuring this relative degree of resistance of the paper to water, and the sheet as it comes off the machine has to show a degree of water resistance demanded by that certain grade in order to be accepted for shipment.

Another method of sizing, used extensively in the manufacture of fine writing papers, is tub sizing, which consists of running the sheet through a vat of starch, wax emulsion or gelatin size. This operation can be seen on No. 8 paper machine at Camas. The size for this operation is made in tanks under No. 8 machine, run into a storage tank and then circulated from the storage tank to the size vat on the machine. This vat, located between the two dryer sections, allows the size to contact the sheet before it has been thoroughly dried. The size, applied to both top and bottom of the web, only partly penetrates the sheet before it is finally dried in the last dryer section and produces a so-called "surface sizing" effect.

Stabilizing of rosin and wax by means of proteins has lately come into commercial importance and is known as the "Prosize" process.

PART III—LOADING

Loading or filler is used in paper to increase its usefulness, especially in producing papers that are to be used for printing or writing. Fillers are used in such grades as bleached envelope, telephone directory, special magazine, news, special book, also in opaque bread wrap in order to improve opacity and general appearance. In printing papers opacity is desired to minimize show-through of printing on the other side of the sheet.

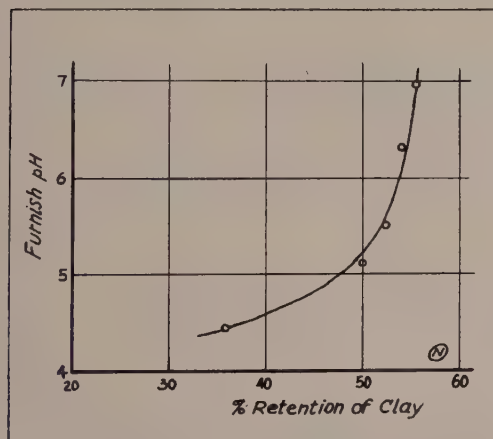


Fig. 86
Retention Test
in a European Mill

Filler also helps in obtaining a smooth, high-finished sheet when the paper is calendered or supercalendered.

The fillers most generally used in the paper industry are clay, talc,

crown filler, chalk, blanc fixe, zinc sulphide and titanium dioxide.

The quality requirements of a good filler include its color, fineness, absorption of grit and dirt, effect of the filler on size, effect of the alum on the filler, and the retention in the finished paper. Its cost and ease of dispersibility in water must also be considered.

A good grade of clay has no effect on the alum, however, it does lower the strength of the paper, and as the percentage of ash increases, the sizing is decreased.

Retention of a filler means the percentage of filler found in the finished paper as compared to the amount put in the beaters and is calculated from ash tests on the paper.

Retention of clay and other fillers is affected by pH and often there is a certain pH value at which the best retention can be secured. For example, Fig. 86 shows the results of tests made in a European mill on this problem, and which showed that retention was at a maximum when the pH was about 6.8. These values, of course, cannot be directly applied to other mills as they are also affected by many other local conditions.

Talc is hydrated magnesium silicate. The talc used at Camas is mined in California, has an excellent color and is very fine. It is air-floated instead of water-floated to remove the grit, and, while it contains some grit and mica, it is not troublesome because of its fineness. Talc gives paper a soft, velvety feel, and gives a good gloss on calendering, but has very little effect on sizing.

Crown filler is a manufactured product, being calcium sulphate with two molecules of water of crystallization, and is sometimes known as pearl hardening. It has excellent color and is low in grit, but is the most soluble, has the lowest retention and the highest cost of any of the fillers. It decreases the sizing due to the calcium sulphate precipitating out the rosin size.

Chalk, or calcium carbonate, is occasionally used on certain grades, such as very thin papers for dictionaries, but it seriously interferes with the rosin size and alum, which makes it impossible to use in a well-sized sheet.

Blanc fixe is barium sulphate, usually a manufactured product with a high specific gravity, and therefore a low retention in the finished paper. It is expensive and is only used in a few grades where a special finish is required. The last three named, Crown filler, chalk and blanc fixe, are not used in Camas operations.

During the past few years a number of new pigments for loading and coating have come into use. The most important, as far as Camas operation is concerned, are the highly refractive pigments used in opaque waxing papers. If a dark brown pigment is present in the paper, it will absorb much of the light and produce opacity, but this is an undesirable condition since it is preferred to obtain opacity by reflection and refraction from a white surface rather than absorption by a darker medium.

In order to understand the meaning of "refraction," consider a small particle of loading pigment in the paper and light striking it at an angle (see Fig. 87) If the index of refraction is the same as paper, the light beam will pass through practically unchanged in direction. However, if this pigment particle has the ability to bend or "refract" light, then the light beam may be successively bent or refracted by a number of pigment particles and finally bent back in the direction from which it came.

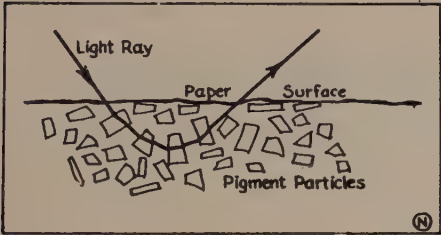


Fig. 87
Refraction of Light Ray

Index of refraction is simply a measure of the ability of a substance to bent light. The refractive index of the common loading materials is as follows:

INDICES OF REFRACTION

Titanium Dioxide.....	2.55-2.74
Zinc Sulphide.....	2.37
Chalk.....	1.56
Clay.....	1.56
Talc.....	1.55
Cellulose or Paper.....	1.53
Paraffin.....	1.43
Air.....	1.00

The ordinary coating pigments, clay and chalk, have refractive index values very close to paraffin wax. In other words, when they are put into the sheet of paper and intimately surrounded with wax, light will pass through practically unbent. For this reason clay or chalk is not used in opaque bread wrap and other opaque waxing papers.

CHAPTER XIII

EVOLUTION OF THE PAPER MACHINE

By E. W. G. COOPER

From ancient records, we find that man has employed various methods of making permanent records of important events and divergent fields of knowledge for future generations.

Some of the earliest evidence of such records is to be found in the inscriptions hewn into rocks, pyramids, column obelisks, tablets of clay, marble, ivory, metal plates, bark, leaves of certain trees; even waxed boards were used. Early Chinese paintings were made on silk prepared with size.

Mummy bandages have been found inscribed with hieroglyphics—a sacred writing of ancient Egyptian priests. Such writings are still to be found today, not only on the grave cloths, but upon the stone columns and immense figures in and around the old temples on the banks of the Nile. It always has been and will be a happy hunting ground for the hieroglyphist, that is, one who can decipher hieroglyphics. There are statues of kings and queens with feet about 11 feet long and legs about 20 feet from sole of foot to knee. The great Temple of Karnak near Luxor has 135 majestic columns all engraved with the history of Kings and Gods and faithfully depicting life in Egypt 5,000 years ago.

The skins of animals, chiefly sheep and goat skins, were used. Parchment and papyrus were actually the forerunners of paper. Parchment was however, more popular than papyrus. Even today, notwithstanding the fact that excellent paper equal in durability to the finest skin parchment can be obtained at a much lower cost, skin parchment is still used for special purposes.

The term "paper," no doubt, has its origin in the close outward resemblance of this material to papyrus. Pliny gives a detailed description of the preparation of papyrus as an industry flourishing in 3,500 B.C. Papyrus is a reed growing from 10 to 15 feet high, the inside pith being used for food and the fibrous part commonly used for cords, mats and clothing. The exact date of its first use is unknown. It was used in 350 B.C. and I believe we have a reference to papyrus in the Bible, quoting from Isaiah 19-7, "The paper reeds by the brooks shall wither and be no more.

The fishers also shall mourn and all they that cast angle into the brooks shall lament." Papyrus was made into sheets by placing one layer across another at right angles, gently beaten and pressed, sized with flour, dried and finally polished."

The method of making true paper, as we know it, consisting of a thin leaf-like fabric prepared by reducing a mass of fiber to a state of minute division and isolating and depositing it from suspension in water by a sieve or screen, was apparently developed by the Chinese in 123 B.C.

The Chinese Emperor Hoti employed a learned Chinese scholar, one Ts'ai-Lun, to invent a new writing material. After 30 years of experimenting with silk cloth and other materials, Ts'ai-Lun succeeded in making a fair grade of paper by beating bamboo and old rags and forming into a sheet. The secret was successfully guarded for 600 years before reaching other lands. Harassed by court intrigue, the inventor finally committed suicide, an inglorious end for the first papermaker.

The bamboo shoots were first treated with lime, then hammered to loosen bark and afterwards bleached by exposure to sunlight and acid. A second boiling was made with lime, but with a weaker solution this time, then the shoots were allowed to stand in heaps so that fermentation might take place. They were again boiled in water, and the fibrous mass put into steeping pits with soda lye until needed for conversion into pulp by prolonged beating with the Tappet system or Stampers and grinding in mortars.

Sheets of paper were made by dipping a mould into a vat of the pulp. The moulds were made of strips of bamboo and silk threads, instead of the wooden frame with strands of wire for laid papers, and wire cloth for wove papers, as we use in the making of hand-made papers today. The sheets were then dried on slabs of plaster of Paris, heated by a fire underneath.

The secret of papermaking found its way from China to Korea and Japan. The latter country, especially, has obtained world-wide reputation for the manufacture of paper remarkable for its strength, durability and finish.

Thanks to the Arabs, the art traveled from East to West. Damascus and Mecca were both centers of a flourishing paper industry at an early date. Many paper mills existed in Egypt during the 10th Century and in Italy in the 12th Century. Paper mills existed in Germany in 1336, erected by the "Bros. Holbein," and in 1390 by "Stromer," a Nuremberg merchant, who while traveling in Italy, was inspired with the idea that paper could be made in Germany and imported papermakers from "Lombardy."

Stromer experienced labor troubles as a result of an attempt to control a monopoly of papermaking. He forced his operatives to swear to preserve secrecy of the process. His foremen were bound by oath to work for their master or their master's heirs for life and also act as bodyguard to their employer and impart the secret of papermaking to no one.

Paper was first made in England by John Tate in 1496. Another early papermaker was John Spielman, a German jeweler, who built a mill at Dartford, Kent, England, and was rewarded by Queen Elizabeth and created a knight for his services to commerce. There is today a monument erected to his memory in the Parish Church of Dartford. Today, in the midst of a large and important papermaking center, there are, within a 50-mile radius, one of the largest News mills in the world, the largest Board mill, one of the most modern Greaseproof mills, and a Vegetable Parchment mill, on the site of one of the first commercial sulphite mills, built by Ekman in about 1884.

Someone dedicated a poetical version (relating to Sir John Spielman) to Sir Walter Raleigh, bearing the title, "A description and playne discourse of Paper and the whole benefits that paper brings with rehearsal and setting forth in verse a paper mill built near Dartford, Kent, by an High Germaine called Master Spilmon, Jeweller, to the Queen's Majestie, beginning,

"I prayse the man that first did paper mayke,
The only thing that sets all Virtues forth."

We have something the same on record in this country. An early American reference to papermaking—a 26 line quotation from Richard Frames, reads "A short description of Pennsylvania on a relation of what things are known, enjoyed and like to be discovered in the said province." It recites the industry of the Rittenhouse mill in Germantown, Pennsylvania, in 1690. Again, the American historian, John Holme, contributed to the literature of papermaking with a bit of verse that did not find its way into print until 1847. The lines appeared under "A true relation of the flourish State of Pennsylvania." The closing lines make a rather terse and eloquent appeal for rags to carry on the art:

"Kind friend, when thy old shirt is rent,
Let it to the Paper Mill be sent."

However, it seems to be 1690 before we commenced to make paper in this country, due to the fact that the paper industry had not gained much headway in the countries from which our forefathers had come, and again, paper was not such a vital necessity to the pioneer as was the task of clearing the wilderness to make townsites and trading with the Indians

for furs. Farming the land for the necessities of family life was more important and these pursuits claimed their time and attention.

Even the starting of the first mill in 1690 was not the result of any urgent call of the community, but a result of the small needs of a printer in Philadelphia and the ambition of a newly arrived German papermaker. Thus began the art of papermaking in U. S. A. In the year 1810 there were 195 mills making paper by hand, with many good examples of water-marking.

Wove moulds were first used by Baskerville in 1757 for paper on which to print his "Virgil." The idea of a wove mould was that you could use a much smaller or finer pulp that would drain without going through. Therefore, in machine made papers today, not only are they watermarked, but the laid lines are reproduced from the dandy, which can either be a laid or a wove or a spiral laid. The dandy in use at Camas is a wove dandy. These first came into use in 1826.

Reverting back to the period 1690 to 1810, when there were 195 mills making paper by hand in this country. Up to the same date, approximately, the papermakers in England were still dipping the mould into the vat but with the introduction of the Hollander at this time, it was possible to prepare the stock much faster. This was some incentive for the mechanical mind of papermakers to devise some mechanical means of speeding up the conversion of stock into sheets, and in fact, became an economic necessity for most grades of paper. It still is today, for example, in the case of news-print where the profit comes at speeds above 1000 F.P.M. Many are running today at 1200 F.P.M., with machines designed to run at 1400 F.P.M.

However, today, after 134 years with the papermaking machine, hand made paper for legal documents, bank notes, high grade writing and loose-leaf ledgers, is still in demand.

The inventor of the paper machine was Louis Robert, a workman in a paper mill in France. He applied for a patent for a machine in 1797. Robert had a legal argument with his employer, Ledger Didot, which was decided in favor of the former. However, Robert transferred his patent to Didot. Robert came to England with his brother-in-law, John Gamble, and obtained a British patent in the year 1801. The Fourdrinier brothers also came to England and took out a patent for a machine in 1806, which was really a chain of moulds from which continuous sheets of paper were made, but only amounted to an experiment. The second machine which, no doubt, had the benefit of previous experiments and ideas of Robert, Perriers, Gamble, the Fourdrinier brothers and a very practical engineer, Bryan Donkin, became the first *practical* papermaking machine, which was installed at Two Waters Mill, Herts, England, in 1804. Experimenting

and improvements continued under the supervision of Bryan Donkin, who spent most of his nights and days in the mill to make this machine a success. This objective was not reached until 1810 to 1812 when it was started on a commercial basis by Marchant Warrell in the presence of Bryan Donkin, January 13, 1812.

The following description of Marchant Warrell is quoted from the "Paper Trade Review," December 3, 1897.

"Judging from his portrait, which is reproduced herewith, Marchant Warrell appears to have been a man of some character and determination, and indeed it required a man of this type for the job. The great majority of papermill workers looked on the advent of the paper machine as a calamity. There were riots, the windows of the mill had to be protected with shutters, and carboys of vitriol were placed on the roof of the mill to pour on the besiegers from neighboring mills, who attempted to destroy the mill. But the machine went on under Marchant Warrell's guidance, and it is to such men as he was that the workmen of the present day should look with respect. He foresaw that greater production would help the working man. This is a lesson that applies quite as strongly today with the shadow of foreign competition threatening our industry."

Following the installation of a number of these machines, various improvements were suggested by other papermakers and engineers and protected by patents. In 1812, the Ledger Didot patent makes mention of the continuous wire, which exists in the modern machine today.

In the same year Thomas Cobb took out a patent for covering the couch roll with a woolen jacket. In 1817 John Dickenson patented the second press or reversed press. In 1820 the idea of attaching drying cylinders to the paper machine was developed by Thomas Crompton. In 1825 John Christopher Phipps took out a patent for a laid dandy roll for producing laid lines on machine made paper, similar to hand made. During this period the manufacture of these machines was entirely in the hands of Byran Donkin under Fourdrinier's patents, and up to 1823 he had built 30 machines.

Then came the rotary strainer or screen, which was in use before the flat screen, then, later, tube rolls and the eccentric motion for the shake.

Let us go back to about the same time when the Fourdrinier brothers, John Gamble and Bryan Donkin were developing their ideas of machine made paper. John Dickinson, of England, invented and patented a cylinder machine about 1809 and in 1807, a patent for a similar machine was granted to Charles Kinsey, U. S. A., Essex, New Jersey. The problem was not solved however, until, after long experimenting, Gilpin was able to take out a patent for a cylinder machine in December, 1816, and in August



Fig. 88 Marchant Warrell

of the following year, put the machine into practical use, running for the first time on this side of the Atlantic, machine made paper. It ran faster than the English Fourdrinier machine and it was said that it was more economical to produce paper on this type. This machine demonstrated what possibilities there were and, of course, was a great incentive to the art of papermaking in this country.

This first cylinder machine was installed in Wilmington, Delaware on the Brandywine. Gilpin carried on for 50 years but decided to give up the business after his mill was destroyed by flood twice and by fire once. I remember my first visit to the Brandywine and the site of Gilpin's mill. It is one of the prettiest spots I have seen. Jessup & Moore have a very nice book mill there now. There is a very nice town with a good library, and there you can get a good insight into the romance of papermaking in the United States.

Let me quote J. G. Scharp's History of Delaware, 1888, briefly, "Citizens and strangers often resorted to this estate for a pleasant walk and to enjoy its beauteous scenery as well as to see the novelty and skill of mechanism. Visit the wonder working machine that could turn out an endless sheet of paper. We will venture to sketch one department in the old mill—a large salle on the lower floor, where more than thirty women were seated on high stools at a long table placed before the windows, each one having a knife to pick the motes from every sheet, and they were dressed becoming their occupation, with a clean apron as smooth as if an iron had just been rubbed over it, not a cobweb marred these white walls nor was dust allowed to soil the floors."

A few years after starting his machine, Gilpin sent samples of his paper, taken from a sheet 1000 feet long and 27 inches wide, to the American Philosophical Society. In 1820 to 1821, he was making paper for letterpress work and copper engravings. This was five or six years before any paper was made on a Fourdrinier in this country. The first one was imported in 1827 by Henry Barclay, of Saugerties, New York. A 60-inch machine was set up there, which ran for 45 years and was destroyed by fire in 1872.

A second Fourdrinier was imported from Buxy, England. After several of these machines had been imported, James Wilcox, of Pennsylvania, said that the machines from England cost too much money and were sometimes imperfect, so they decided to make their own, and the first one was made by Smith & Winchester Company, South Windham, Connecticut, in 1829.

It seems, however, that while the Fourdrinier was being developed in Europe, the United States went ahead with the cylinder machine, which accordingly, gained more favor here than elsewhere. The cylinder machine

today has as many as seven forming cylinders, up to 185 inches wide used for making box board and card stock.

It is recalled that an imitation two cylinder sheet was once made on a machine, with two flow boxes, one of which delivered stock on top of the wire at the suction box, and sometimes applied a coating of color on the dandy.

Another development was the use of three Fourdrinier wet ends, one over the other, each making a sheet of paper independently up to the couch when it was delivered to a felt and the three felts each transferred its respective sheet of paper to a common combining press.

Another modification was to have a cylinder machine in the first press felt pit, so that when the sheet was transferred from bottom couch to wet felt, it was combined with a sheet on the felt picked up from the cylinder.

Later, machines were made to imitate hand-made paper. First the cylinder machine was modified, in order to make what is known as mould made paper. Rubber bands were placed around the mould to effect a deckle edge as in hand made sheets. The laid lines were reproduced by use of the laid dandy. Next was the "John Annendale" patent for a suction box adjacent to the slice to set the stock as soon as it engaged with the wire cloth, with the idea of obtaining tear and tensile even both ways as in hand made paper. "Whatman" had a Fourdrinier machine for rag writings, drawing, etc., which had a unique shake that was made to shake the sheet both ways. Other mills have made paper one sheet at a time by machinery, very difficult to tell from hand made. There is a mill called Hawley Paper Mill, near Dartford, Kent, England, where no outsiders could get a look. There were no windows for any "Peeping Toms" and the process was a secret. No operative could get familiar with the complete cycle of operations. It is said that the sheet was passed from one room to another on a conveyor through a slit in the wall and on some of the operations only single men would be employed as they would have no wives to talk and everyone was under a contract and sworn to secrecy.

One could speak of many old-time practices as one reviews them. However, it makes us appreciate all the more the up-to-date and efficient machinery we have here. In the early days, the dryers were heated by burning wood inside. Later they were gas heated, then by steam, and even then they were rough cast inside with an uneven thickness in shell. Now they are machined inside and out and usually cast in one pouring. We have today chromium plated dryers for some specialties.

I remember about nineteen years ago we had a machine for the manufacture of Photographic Print Paper. The face of the dryer was then

nickel plated and doctored with a Vickery doctor with a strip of wood instead of steel. The drive gears were located in another room. The dryers were constructed with a long shaft on the driving side, which extended through holes in the wall and keyed to the gears in mesh with the rest of the drive, so that no metallic dust from gears would contact the paper. Pipe lines for stock and water were of copper lined with porcelain.

On some machines 60 years ago and in use even 30 years ago in a very old mill in Canada, the gears were inside the frame, so that if the felt went to the backside, it was in the cogs, lifting the top dryers out of their bearings.

Some of the readers may remember, too, when to change speeds it was necessary to change a set of gears on the engine crank shaft with no hoist to lift them.

The story is told of a short and fat machine tender in an old mill here in the United States. He heard that they had decided to buy another set of gears so that the machine could be speeded up another 10 feet. He expressed himself as only papermakers can, and said, "Well, when they speed machines up faster than a man can walk, it's time to quit his job," and he did.

My first experience with crepe papers was in a rag mill, making high grade card stock, cover paper, cheque, drawing, etc. We would crepe on the press, which crepe was afterwards partly pulled out in the dryers and calender rolls. In addition various devices at the slice and on the dandy, giving various colors and two-tone effects, were used, making a very expensive greeting card. We made our crepe without any jackshaft, cone pulley or expansion pulley. We lagged the main drive pulley with 10 to 14 ply of old felt, stuck with a combination of resin and black grease and tied with cord, to slow the dry end down. When going off crepe, we would stand over the belt with pails of boiling water and shrink it up.

We used to put a wire on Saturday morning and the foreman would come around and ask us boys what brand of cigarettes or tobacco we wanted. Also the kind of soft drinks for the minors and dark or light beer for the men. This was brought in the mill and we would sit at the back side of the machine, smoke, drink and dream of the papermaker's final reward in Paradise when he could stand by the press section or near the wire, press a button, and presto, he could raise a press roll, tighten or slack his felts, change a draw between any section of the machine, raise or lower the top couch, or the whole Fourdrinier as a unit, change the pitch of the wire, start or stop any of the pumps and still pass the buck to the beater room if he did have a bad day. That is exactly where we are today after over a century of progress from the first "old lizzie" to the present day's "Rolls

Royce," which is not confined to newsprint alone, but book, tissue, kraft, bonds and boards.

One of the outstanding inventions of our day in connection with the Fourdrinier is the Minton dryer. It cannot be excelled for pulp drying, but it is limited in its suitability for hard-sized papers unless the sizing is done by the solvent sizing process. Paper is dried at a comparatively low temperature, below the melting or fusion point of resin, and with a vacuum of 28 inch mercury.

This is an American contribution and there are many others that America has given us, making it possible to attain high speeds: Consistency Regulators, Automatic Steam Regulators, High Pressure Stock Inlets, "Voith" and "Van de Carr" Slices, etc.

The largest board machine in existence today was built in this country by the Beloit Iron Works and installed in the world's largest board mill, Thames Board Mill, Purfleet, Essex, England.

The Bowater Lloyd Mill, at Sittingbourne, Kent, England, has among 21 machines, one of the world's largest paper machines, built by Walmsley's to run at 1400 feet per minute. The width of the machine is 320 inches and the wire is 100 feet long. The suction couch and suction press rolls are 44 inches in diameter.

We are not through with superlatives yet. The Lloyds mill has the largest Cameron Winder and the largest supercalender in the world. The supercalender will finish paper 306 inches wide at a speed of 2300 feet per minute. It is a 10 roll stack, the bottom roll being 3 feet in diameter and weighing 60 tons.

This chapter on the evolution of the paper machine is to develop a proper background and contrast for the succeeding chapter describing in detail modern papermaking equipment. It has been a long and difficult road since 1690 and the paper machine in its present state of development represents the combined labor and skill of many distinguished and honored paper makers.

137 Years of Progress in Chronological Order from 1799 to 1938

1799

On January 18, 1799, the Government of France granted Nicolas Louis Robert a patent on a machine for making sheets of paper at very large size, even 12 feet wide and 50 feet long. Robert was a machinist connected with Didot's paper mill at Essonnes. During this same year a working model of the machine was constructed, but its work was not fully satisfactory.

1801

Leger Didot, of Essonnes, France, agreed to purchase this patent and model from Robert and accompanied by John Gamble, an Englishman, sailed for England. In England, Didot secured the aid of Bryan Donkin, a man of considerable mechanical skill, and by means of experiments and observations of the trio—Didot, Gamble and Donkin—the patent of Robert was perfected. On April 2, 1801, a patent was granted in England to John Gamble for an invention for making paper in single sheets without seam or joining, from one to twelve feet and upwards wide, and from one to forty-five feet and upwards in length.

1804

Henry and Sealy Fourdrinier, stationers and manufacturers in England, purchased the interest of Didot and Gamble in the improved Robert machine. During this year another successful machine, practically a duplicate of the first, was put in operation in "Two Waters Mill," Hertfordshire, England. This machine was run by Marchant Warrell, who thus became in reality the first machine tender.

1806-8

Henry Fourdrinier was granted a patent in England on July 24, 1806, for "The Method of Making a Machine for manufacturing paper of an indefinite length, laid and wove with separate moulds." On August 14, 1807, an act of the British Parliament gave an extension of the patent rights obtained by the Fourdriniers. During the year 1808, John Gamble assigned to Messrs. Fourdrinier all his rights in the patents as extended by the Act of Parliament, thus making them the sole proprietors of the patents covering the only successful papermaking machine in existence. So the machine invented by Robert, improved and promoted by Didot and Gamble, designed by Donkin and financed by the Fourdriniers, came to be known and continues to be known as the Fourdrinier machine.

1812

Thomas Cobb took out a patent in England for covering the couch roll with a woolen jacket.

1817

John Dickenson patented in England the second press.

1821

John C. Phipps took out in England the first patent for a dandy roll for producing laid lines on paper.

1823

Steam cylinders for drying paper were first used by Thomas B. Crompton in England.

1826

Mr. Canson, in England, applied suction pumps to the Fourdrinier machine to cause a suction underneath the wire on which the paper was formed, in order to assist in the removal of water.

1827

The first Fourdrinier papermaking machine in the United States was imported by Henry Barclay. It was built in England by Bryan Donkin and had a width of sixty inches. This machine was installed in a mill in Saugerties, New York, and started up on October 24, 1827.

1828

The second Fourdrinier machine in America was installed in the mill of Joseph Pickering in North Windham, Conn. This machine was set up under the direction of George Spafford and started up early in the year.

1829

The first Fourdrinier paper machine to be built in America was constructed in the shop of Phelps & Spafford, now the Smith & Winchester Manufacturing Company, in South Windham, Conn. This machine was installed in the mill of Amos H. Hubbard, at Norwich Falls, Conn., and went into successful operation in May, 1829. This plant was the first paper mill in Connecticut, having been founded in Colonial days, about 1768, by Christopher Leffingwell.

1830

A patent was taken out in England by Thomas Barratt for various improvements in the paper machine. He also introduced the tube rolls, the eccentric motion for the shake and a compensating reel frame for the dry paper.

1840

In this year Thomas Barratt introduced the idea of improving the drying on a paper machine by blowing jets of air against the paper on the drying cylinders.

1853

The first paper machine to go west of the Mississippi River was a Fourdrinier built for Samuel P. Taylor by Smith & Winchester Company at South Windham, Conn. The machine went by boat to Panama and was shipped on skids across the Isthmus. Then by schooners to Bolinas, near

the mill, whence ox sleds hauled it along a mountain ridge and down to the site in Taylorsville, California.

1860

About this date, Smith & Winchester Company built the first Jordan engine, which they sold to Boswell Keene & Co., of East Hartford, Conn.

1862

The Harper Fourdrinier machine was patented by James Harper, of East Haven, Conn.

1864

The first rubber covered bottom press rolls came into use. Prior to this time, the rolls were of wood, iron or composition.

1867

About this time chilled iron calender rolls came into use. Before then ordinary cast iron rolls were used. Prior to 1867, the widest machine was not over 100 inches and speed not more than 100 feet per minute.

1876

About this date Jouffray Cadet & Son, of Paris, France, invented the cone pulley and bevel geared drive for operating paper machines. Later this drive was introduced in the United States by George E. Marshall, of Turners Falls, Mass., who had obtained a U. S. patent for it. This drive has since been known as the Marshall Driving Train.

1879

The diaphragm screen was invented about this time by Edmund Victory, superintendent of the Remington Paper Company at Watertown, N. Y.

1887

Warren Curtis, of the Hudson River Pulp & Paper Company, prepared specifications for a machine to be placed in Palmers Falls Mill to have a wire 112 inches wide by 50 feet long, and 22 48-inch dryers in two tiers. The machine was built by Pusey & Jones and designed to run at 250 feet per minute. It was installed in 1887 and 1888, and was the widest machine at that time. This machine is still in operation, running at 490 feet per minute.

1889

Lloyd's Mill at Sittingbourne, England, a machine having a wire 120 inches wide by 40 feet long, and 20 dryers ran at 270 feet per minute.

1892

Willamette Pulp and Paper Company at Oregon City, Oregon, a

Bagley & Sewell machine ran at 480 feet per minute. Up to 1896 the widest machine was 160 inches and the highest speed run 500 feet per minute.

1896

Rumford Falls Paper Company at Rumford Falls, Maine, installed a machine built by Rice, Barton & Fales with a wire 162 inches by 60 feet, three presses and twenty-four 48-inch dryers. For several years this was the widest machine.

The first Millspaugh shower pipes were installed in a Fourdrinier machine of the Glens Falls Paper Mill Company at Glens Falls, N. Y.

1897

Mills at Glens Falls and Palmers Falls, N. Y., Berlin, N. H., and Oregon City, Oregon, claimed to be running machines at 500 feet per minute.

1900

St. Regis Paper Company, Deferiet, N. Y., a 90-inch Bagley & Sewall machine ran at 525 feet per minute.

1902

Remington Martin Company Mill, Norfolk, N. Y., a 100-inch Bagley & Sewall machine ran at 535 feet per minute.

1903

Remington Martin Company Mill, a Bagley & Sewall machine with a 163 inch wide by 65 foot long wire ran at 460 feet per minute.

1904

Berlin Mills Company (now Brown Company), Berlin, N. H., installed four 164-inch Bagley & Sewall machines for making newsprint. These were the widest machines at this date.

1908

The first installation of a sectional electric drive was on a 112-inch Bagley & Sewall Fourdrinier machine in the plant of the Gould Paper Company at Lyons Falls, N. Y. This consisted in the removal of the mortise bevel gear with cone pulley intake drives and substituting individual variable speed, direct current motors. A spur pinion on the motor shaft meshed with a large gear on the indriving shaft. Each motor had hand operated rheostat controls.

1908

Late in December, the first Millspaugh suction couch roll for a Fourdrinier machine was installed in the mill of the Hammersley Manufacturing

Company at Garfield, N. J. The machine had a wire 96 inches wide, three presses and 24 dryers. A cycloidal rotary vacuum pump was used to create suction in the couch roll. Greaseproof paper was made.

1909

Minnesota and Ontario Paper Company's mill at International Falls, Minnesota—two Pusey & Jones machines with 184-inch wires were installed. These machines were equipped with 60-inch diameter dryers and this was the first installation where dryers of that size were used.

1909

On December 27, in the mill of the Cliff Paper Company at Niagara Falls, N. Y., the first Millspaugh suction couch roll to run on newsprint was started up. The machine had a wire 90 inches wide by 40 feet long, two presses and 16 dryers.

1910

Very early this year compressed air was first used to handle the sheet from a Millspaugh suction couch roll to the first press of a Fourdrinier making newsprint in the Niagara Falls mill of the International Paper Company.

1911

Speeds of paper machines making newsprint had risen to 700 feet per minute.

1911

On May 10, the first Millspaugh suction first press roll in any paper machine was started up in the mill of the Cliff Paper Company at Niagara Falls, N. Y., and was in the same machine that the suction couch roll was installed in 1909.

1912

Lake Superior Paper Company's mill at Sault Ste. Marie, Ontario—two Pusey & Jones machines having wire widths of 196 inches were installed. These were the first machines for making $2\frac{1}{2}$ roll sets of standard width newsprint paper.

1912

Late in 1912 the Ontario Paper Company at Thorold, Ontario, installed two Pusey & Jones machines with 200-inch wide wires. For several years these were the widest news machines.

1913

William Sheahan, superintendent of the Williamette Pulp & Paper Company, installed a Sheahan automatic paper carrier on the dryers of a

paper machine in the mill of that company at Oregon City, Oregon.

1914

Great Northern Paper Company at Millinocket, Maine, installed a Rice, Barton & Fales machine having a wire 158 inches wide by 92 feet 9 inches long sloping 24 inches, two regular presses, thirty 72-inch diameter dryers and a Pope uniform speed reel. The table rolls were carried in ball bearings and air was used to handle the paper from the wire to first press. This was the first large installation on a paper machine of anti-friction bearings and the first use of 72 inch diameter dryers. This also was the first installation of a Pope uniform speed, drum reel. The Fourdrinier portion of the machine was built in sections each carrying a group of table rolls and could be pulled out on rails. This was the first attempt at a removable Fourdrinier.

1915

The first Nash vacuum pumps installed in a paper mill were in the plants of the S. D. Warren Company in Maine. In March, 1915, a pump was installed in conjunction with a 90-inch Millspaugh suction couch roll at Cumberland Mills and in November, 1915, a pump was installed in the Gardiner mill to create vacuum in the boxes on the wire of a Fourdrinier machine. Book papers were made on both machines.

1919

In the Pacific Mills Company plant at Ocean Falls, B. C., Canada, a 204-inch Bagley & Sewall machine ran at 735 feet per minute.

1919

Abitibi Power & Paper Company at Iroquois Falls, Ontario, installed a machine having a wire 232 inches wide by 80 feet long, three presses, and thirty 60-inch dryers. This is the widest machine at this time and the first for making a set of three standard width rolls of newsprint paper. The machine was built by the Charles Walmsley & Company in Bury, England, and was driven through Lloyd-Hutchinson type mechanical drives using ropes and belts.

1919

In November the first sectional electric drive in America to be equipped with automatic means of speed regulation was applied by the Westinghouse Electric & Manufacturing Company to a 148-inch Bagley & Sewall Fourdrinier paper machine in the plant of the Gould Paper Company at Lyons Falls, N. Y. The machine had a couch, three regular presses, thirty-two 48-inch diameter dryers, one 8-roll calender stack and a 2-drum reel. The speed was from 500 to 600 feet. Newsprint was made on the machine.

This machine first went into operation in 1911 and was equipped with individual direct current, spur gear reduction motors with hand operated rheostat controls. The hand controls were replaced in 1919 with automatic means of speed regulation as previously stated.

1920

The first commercial paper of any kind to be made at a speed of 1000 feet per minute was run in Wausau Sulphate Fibre Company's plant at Mosinee, Wis., on October 23, 1920. This was a lightweight kraft paper, made on a machine built by the Bagley & Sewall Company, having a wire 112 inches wide by 70 feet 6 inches long, suction couch, suction press and sixteen 60-inch diameter dryers equipped with a Sheahan carrier. The machine had a mechanical drive with a variable speed motor direct connected in about the center of the line shaft.

1920

The first suction second press roll was installed in a machine built by the Downington Manufacturing Company for the Hinde & Dauch Paper Company at Fort Madison, Iowa. The machine had a wire 142 inches wide by 75 feet long, suction couch, two suction and one regular press, with sixty 42-inch diameter dryers. All suction rolls were Millspaugh and 9-point straw paper was made.

The first suction second press roll on news was installed in a 104-inch Fourdrinier of the Crown Willamette Paper Company and was a Millspaugh roll. The machine had a Millspaugh first suction press roll as well.

1921

On April 15, the first commercial newsprint paper to be made at a speed of 1000 feet per minute was run in the Millinocket mill of the Great Northern Paper Company on a Rice, Barton & Fales machine having a wire 158 inches wide by 95 feet long, sloping 54 inches, a 30-inch straight slice, regular couch, four regular presses, thirty-six 72-inch diameter dryers, Pope reel and a two-drum winder. Pope air appliances were used for handling the sheet, beginning with couch and ending with the reel. The machine was operated by a back line shaft driven with ropes from a Corliss type steam engine. The several intake shafts were run by beited quarter turns known as the Ferguson drive.

1921

The Consolidated Water Power & Paper Company at Wisconsin Rapids, Wis., started up a new paper machine built by the Beloit Iron Works, having a wire 160 inches wide by 100 feet long with the Fourdrinier portion removable. This was the first installation where the entire table

from the breast roll to the guide roll, inclusive, was removed as a unit and by a motor.

The first commercial newsprint paper made in Canada at a speed of 1000 feet per minute was run in the plant of the Laurentide Company at Grand Mere, Quebec, in August, 1921. The machine had a wire 166 inches wide by 103 feet long, sloping 32 inches, slice 36 inches high, suction couch, suction first press, two regular presses, forty 72-inch diameter dryers, Pope reel and a two-drum winder. The machine was built by the Dominion Engineering Works and driven by a Harland Sectional Electric Drive with automatic speed control and regulation.

1923

The first Voith high slice or pressure stock inlet with a straight lip in the United States was installed in November on a 196-inch wide machine of the Kimberly-Clark Corporation at Niagara Falls, N. Y. The slice was 28 inches high. About this same time, the first commercial Van de Carr slice with curved lip was being built by the Dominion Engineering Works for a 234-inch wide machine of the Kenora Paper Mills, Limited, at Kenora, Ontario. This slice was 46 inches high and the machine went into operation in the spring of 1924. The experimental work for the Van de Carr slice was done in 1921 on a 166-inch machine of the Laurentide Company at Grand Mere, Quebec, Canada. This slice was 36 inches high and was the first one of this type to be used on a newsprint machine on this continent.

1923

A new design high speed shake was installed on a new machine of the Filer Fibre Company at Filer City, Michigan. The machine was built by the Beloit Iron Works, has a wire 160 inches wide by 80 feet long and is arranged for speeds up to 800 feet per minute. Kraft papers are made on the machine. This style of shake is in successful operation on a machine having a wire 251 inches wide and arranged for speeds to 1000 feet per minute, making kraft papers. This shake has greatly improved formation of the sheet, thereby permitting increased speed in making the finest book papers as well as kraft papers.

1924

The first suction second press roll for newsprint in Canada was installed in February in a machine of the Laurentide Company at Grand Mere, Quebec. The size of wire was 124 inches wide by 65 feet long. This was a Kilberry roll and built by Downingtown Manufacturing Company. The machine had a regular couch, regular first, suction second and regular third presses with twenty-eight 48-inch dryers and ran at approximately 600 feet a minute.

1925

Kenora Paper Mills, Limited, at Kenora, Ontario, installed a Bagley & Sewall machine having a wire 245 inches wide by 75 feet long, suction couch, one suction, two regular presses and forty 60-inch diameter dryers. The machine was designed for a maximum speed of 1000 feet per minute and was operated by a Harland sectional electric drive. This was the widest machine at that time.

1926

The Canadian International Paper Company at Gatineau, Quebec, Canada, installed a machine built by the Dominion Engineering Works, having a wire 270 inches wide by 85 feet long, suction couch, one suction, two regular presses and forty-six 72-inch diameter dryers. The dryers of this machine were driven by totally enclosed worm gears. It was the widest machine at that time and was operated by a sectional electric drive made by the Canadian General Electric Company.

1926

In December the first Minton Vacuum Dryer for drying paper in a vacuum was installed in the mill of Price Brothers & Company, Limited, at Kenogami, Quebec, Canada. The dryer contained twenty 60-inch diameter by 152 inch face dryers and was equipped with one top and one bottom felt together with hand and automatic felt stretchers. The wet end of this machine had a wire 156 inches wide, couch roll and three presses with granite top rolls and rubber covered bottom rolls. The machine ran at about 700 feet per minute and made standard newsprint paper.

1927

In May of this year—England—world's largest supercalender. 232-inch face. Northfleet, Kent, England.

In August, the first suction second press roll in a new three-roll wide machine was started up in the plant of the Ste. Anne Paper Company, Limited, at Beupre, Quebec, Canada. The wire was 234 inches wide and was equipped with suction couch and suction first press rolls as well.

September, 1927, Canada

In September of this year—Bertrams Ltd., Edinburgh, Scotland—the world's largest combination machine comprised of usual wet end with rubber covered bottom couch, first and second standard presses, five preheating dryers, then 12-foot diameter M. G. Dryer with press and embossing rolls and English reel. A nest of 12 dryers, calender stack, English reel and Cameron winder.

1927

With a new 224-inch wide newsprint machine of the Fort Frances Pulp & Paper Company at Fort Frances, Ontario, Canada, was installed a self-unloading two-drum winder which automatically ejects the finished rolls of paper and lowers the set down to the floor, doing away with the use of crane or hoist. The machine was built by the Beloit Iron Works.

1928

The widest Fourdrinier machine for making kraft papers was built by the Bagley & Sewall Company, for the National Paper Products Company, Port Townsend, Wash. It has a wire 251 inches wide by 90 feet long, Beloit shaking and removable Fourdrinier part. Suction couch and suction first press roll. Two regular presses. Smoothing press. Forty-four 60-inch dryers. Eight-roll stack of calenders. Uniform speed reel. Two-drum winder with automatic unloader. Westinghouse sectional electric drive. Machine designed to operate at 1200 feet per minute.

The widest Fourdrinier machine for making sulphite bond papers was built by the Bagley & Sewall Company for the Grays Harbor Pulp & Paper Co., Hoquiam, Wash. It has a wire 202 inches wide by 90 feet long. Shaking and removable Fourdrinier part. Suction couch roll. Three regular presses. Smoothing press, forty dryers, 60-inch diameter. One 8-roll stack of calenders. Uniform speed reel. Two-drum winder with automatic roll unloader. Westinghouse electric sectional drives. Machine designed to operate at 1000 feet per minute.

1929

The widest Fourdrinier machine making tissue papers is in the Northern Paper Mills at Green Bay, Wis., with a 194-inch wide by 60 feet long wire, running at 850 feet or more per minute on 10-pound tissue. The machine has a special type pickup couch roll, 30-inch diameter suction press and a 30-inch diameter special creping press, twenty 60-inch dryers, a three-roll calender stack, special reel of the uniform speed type for tissue and creped papers, and a high speed two-drum winder. The drives are enclosed spiral bevel gear type. The dryers are operated by an improved chain drive. The machine is entirely equipped with roller bearings with exception of the three calender rolls, and is driven by a variable speed steam turbine. It is arranged for a paper speed of 1200 feet a minute and has operated at that speed several times. The machine was built by the Beloit Iron Works.

1929

The widest Harper Fourdrinier machine for making tissue papers was built by the Bagley & Sewall Company for Moyer & Pratt, Inc., Lyonsdale, N. Y. It has a wire 170 inches wide by 45 feet long. Adjustable lip high

slice. One press. Pick-up felt attachment. Fourteen dryers, 60 inches diameter. Four-roll stack of calenders. Special uniform speed reel. Special two-drum winder. Mechanical driving train with inclosed spiral bevel gears. Machine designed to operate at 1000 feet per minute.

1929

Great Lakes Paper Company, Fort William, Ontario, Canada, started up in May, 1929, a 304-inch Bagley & Sewall machine which runs about 1070 feet per minute. This is the widest machine yet built and has a wire 304 inches wide by 90 feet long, a suction couch, suction first press and two regular presses, forty-eight 60-inch dryers. It is equipped with Sheahan carriers on third press and dryers and is operated by a sectional electric drive built by the Canadian General Electric Company.

1930

The widest cylinder machine making board is in the Brown Paper Mill Company's plant at Monroe, La. It was built by the Pusey & Jones Corporation and has five 60-inch diameter by 176-inch face cylinders, six primary and three main presses with fifty-seven 60-inch diameter dryers.

1930

England. 245-inch supercalender for 1600 F.P.M. and 30-inch diameter dandy rolls for news.

Beloit Iron Works development of rubber covered suction press rolls.

1931

The speed of paper machines making newsprint has risen to over 1200 feet per minute. One of the latest built, three-roll wide machines, operating twenty-six days during the month of May, 1931, at an average speed of 1203 feet per minute on an average trim of 207.5 inches, had an average daily production of 141.0 tons of standard newsprint paper. Maximum and minimum days run, 155.9 and 122.2 tons, respectively.

England. Largest supercalender now 252-inch face, 1850 F.P.M.

1933

World's largest board mill, London, England, increasing capacity by installation of the largest board machine built by Beloit. 185 inches wide.

Lloyd's Mill, England, have ordered from "Walmsleys" the largest news machine to run at 1400 F.P.M. and 320 inches wide, and another supercalender from Walmsleys with a working face of 310 inches.

Camas, Wash. John Ziegler introduced a new automatic felt guide.

1936-1938

The "dandy" type table roll was developed, making it possible to run free stock at higher speeds. This roll is from 14 to 18 inches in diameter and is covered with wire in the same manner as a dandy roll.

The dual press was introduced, which eliminates a draw between the first and second press rolls and conserves floor space. In this press, two top press rolls are held against a large bottom roll either by spring tension or hydraulic pressure.

CHAPTER XIV

PAPER MACHINES

By H. E. OSTENSON and E. W. G. COOPER

The fabrication of a sheet of paper is in many ways like the making of textiles. Both have their problems of sizing, coloring, loading, water-proofing and "formation." There is an important difference, however, in the respect that textiles are comparatively high priced products while paper is a low value high volume commodity. For example, a paper machine 240 inches wide operating at 1000 F.P.M. will produce a square mile of paper in less than 24 hours. To produce an equal area of textile product in the same time requires several thousand machines.

While quality is of primary importance, the trend in paper machine design and operation is towards wider webs and higher speeds. While the range of specialty papers at Camas is not adapted to heavy volume of less critical grades, like newsprint, it is possible to make 135 tons a day of kraft papers on one machine alone.

Description of a Paper Machine

Before discussing in detail the construction and operation of the various parts of a paper machine, let us look at the machine as a unit. Fig. 90 shows a typical Fourdrinier machine and for reference in subsequent discussion its principal parts may be listed as follows:

THE FOURDRINIER PAPER MACHINE AND NAMES OF ITS PARTS

1. The flow box.
- 1a. The apron board for regulating the flow of the stock to the Fourdrinier wire.
2. Breast roll.
3. Upper couch roll, usually made of metal and covered with a felt jacket; the duty of this roll is to press the mass of stock into compact form, and after leaving the couch rolls the stock becomes a sheet of paper.
- 3a. Bottom couch roll; the Fourdrinier wire laps one-half way around this roll, and the roll being driven in turn drives the wire.

4. Table rolls carry the Fourdrinier wire and thus present an approximately level surface upon which the stock is formed into a sheet; their contact with the moving wire assists in gradually removing a portion of the water from the stock while the sheet of paper is being formed.
5. Guide roll, actuated by an automatic device for keeping the wire in a central position.
6. Stretch roll, vertically adjustable, for keeping the wire at a proper and uniform tension.
7. Rolls for carrying the wire.
- 7a. Hand guide roll, with which the operator can assist the automatic guiding device in keeping the wire in a central position.
8. Dandy roll, used for smoothing the stock, and assist in laying the top fibres.
9. Deckle wash trough, for washing and wiping off particles of stock which may adhere to the deckle straps.
10. Deckle wheel, with flanges on sides to carry the deckle straps.
11. Deckle pulley, preferably of wide face, say eight or ten inches, to carry the return ends of the deckle straps.
12. Slices, for regulating the height of stock on the wire, thus determining the thickness of the finished sheet of paper.
13. Deckle frame, for carrying the deckle pulleys, wash trough, slices, and means of adjusting the deckle arrangement to determine the proper width of sheet of paper to be formed.
14. Deckle straps, made of pure rubber, generally about two inches square, resting directly upon the Fourdrinier wire, to prevent the stock in its liquid state from running over the edge of the Fourdrinier wire.
15. Deckle support, for carrying the deckle strap.
16. Shake rail, generally covered with brass, on which the deckle frame is supported, and to the under side of which the table roll bars are secured.
17. Stationary rails, similarly brass cased, for carrying the deckle pulleys for return of deckle straps; the dandy roll, suction boxes and some of the wire carrying rolls. This portion of the Fourdrinier part does not shake, and these rails derive their name from the fact that they are stationary.
18. Table roll bars, which carry the table roll bearings and the

THE FOURDRINIER PAPER MACHINE AND NAMES OF ITS PARTS

3RD PRESS

1ST PRESS

2ND PRESS

ONE DRYER 20" x 100"

THIRTY DRYERS 48" x 100"

DRAWN ESPECIALLY FOR THE PAPER MILL.

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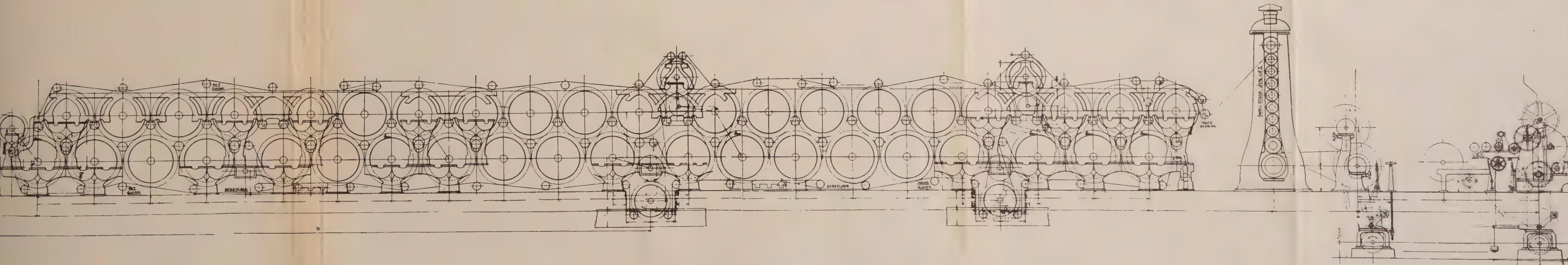


Fig. 90 Elevation of Paper Machine

patented device for preventing the undue sidewise motion of the table rolls.

19. Suction boxes, made of brass with perforated covers of wood, hard rubber, brass or bronze, as the mill owner may prefer. A vacuum being formed in these suction boxes, by use of a pump or other satisfactory device, removes by suction still more of the water from the stock, leaving the fibres lying on the wire in a sheet.
20. Wire stretcher, which, in conjunction with stretch roll, (6) enables the operator to keep the wire at the required tension.
21. Save-all boxes, made of wood, in sections, for catching the water removed from the stock by the table rolls. This water contains particles of stock and is returned to the screens or other desired point to be used again.
22. Save-all stands, for supporting the save-all boxes.
23. Vertical supports for breast roll end of Fourdrinier part; made of spring steel and positively anti-friction.
24. Shower pipes, made of brass tubes, with single or double row of perforations, through which water, under pressure, is forced; for cleaning particles of pulp or stock from return of wire.
- 24a. Shower pipes, used for reducing foam or froth at the slices and in the flow box.
- 24b. Cut squirt or water jet, with one opening for a single stream of water and arranged to travel across the machine. In case the paper breaks and while the Fourdrinier wire is in operation this jet is used for cutting the paper and forming a diagonal end to enable the operators to conveniently carry the sheet of paper over the different parts of the machine.
25. Doctor, usually made of wood, and attached to wire rolls outside of the wire for removing from the rolls particles of stock which may have been transmitted to them from returning wire.
26. Couch housings.
27. Bell-crank arm, for supporting and handling the top couch roll.
28. Hand wheel, by means of which, in conjunction with geared screws, the top couch roll may be raised from direct contact with the wire.
29. Beams, or boards, for facilitating the placing and removal of the suction boxes.
30. Bar, extending across the machine, and carrying palms against which the wire will come in contact when it has a tendency to

run other than in a straight line; the contact of the wire against the palm actuates the automatic guiding device, which, in conjunction with guide roll, (5) guides wire back into a central position. Following the Fourdrinier part comes the presses, in the case of the machine above illustrated, there being three pairs, the pair nearest the Fourdrinier part being known as the first press, the next pair as the second press, and the last pair the third press. Between the rolls of each press the wet sheet of formed paper is passed, carried on a woolen felt, and, by means of pressure applied to the top rolls, more water is removed from the sheet.

31. Top press rolls of first and second presses, in this instance both being made from a wooden log. The rolls can be made of smooth cast iron, chilled iron, brass cased or rubber covered, to suit the views of the mill owner. It is, however, deemed advisable to use wooden rolls for the first press at least, and oftentimes, for the second press also, as the wet sheet of paper has less tendency to stick to the special wooden rolls than when metal rolls are used.
- 31a. Top press rolls for third press, usually made of metal, cast iron, chilled iron or brass cased.
32. Bottom press rolls, usually made of cast iron covered with rubber; the softer surface of rubber lessens the wear of the felt, and also, as these rolls are driven, assists in easily driving the top rolls.
33. Press doctors, having hard wood, brass or hard rubber blades, which in contact with the top rolls remove the stock which may adhere to the rolls and prevent such particles from being impressed into the sheet of paper. These doctors are slowly vibrated to prevent the contact of the blades from scoring or marking the surfaces of the upper rolls.
34. Press housings.
35. Bell-crank swing arms, for raising and controlling the upper rolls.
36. Hand wheel, which, in connection with geared screws, enables the operator to raise the top rolls from contact with the bottom ones.
37. Couch and press frames, for supporting the couch and press housings, rolls and equipment.
38. Felt suction box, generally used for removing air from between the surfaces of the felt and paper before entering first press.
39. Save-all boxes, under the bottom press rolls to catch the water pressed from the wet sheet of paper.

40. Felt whippers, in this instance used in first and second presses. A spray of water is showered on the returning felt from shower pipes. (24) located near the whippers, and the blades or arms of the rapidly revolving whippers beat the felt and wash or free it from particles of stock and other dirt.
41. Felt whipper bearings, made of blocks of wood, for water lubrication, for supporting the felt whippers.
42. Felt stretcher.
43. Hand wheel for operating the felt stretchers to enable the operators to keep the felts at uniform tension.
44. Felt rolls for carrying the press felts.
45. Stretch rolls, used in connection with felt stretchers, (42.)
46. Felt guides, for automatically keeping the felt in a central position.
47. Paper rolls, at third press, for carrying the sheet of paper independently from the felt. These rolls are generally driven by means of belts on the paper which might be caused by the paper revolving the rolls.
48. Foot boards, extending across the machine, to enable the operators to properly handle the paper and manipulate machine.

W— in the Fourdrinier part, is the Fourdrinier wire.

F — in the press part, is the press felt.

From the foregoing it is seen that a paper machine consists essentially of a fine mesh bronze wire to which is supplied a thin suspension of fibers. By means of shaking and suction, a mat or sheet of fibers is formed which passes through a series of press rolls to squeeze out the excess water, then to the steam dryers where the paper is dried to a specified moisture content. The gloss or finish is applied by a stack of chilled iron calender rolls, following which the web is wound up on a reel to be subsequently cut into rolls of proper size on a winder.

Starting Up a Machine

Let us consider next the various steps necessary in starting up a paper machine.

The machine tender first has the engineer start the engine, or motors which drive the line shaft, pumps and auxillary equipment. It is

important to get the condensate pumps started first and have the dryers rotating before turning on the steam. The reason for this is that the dryers will be partly full of water after a shutdown and turning the steam on under these conditions would cause unequal expansion and possibly seriously distort the shell.

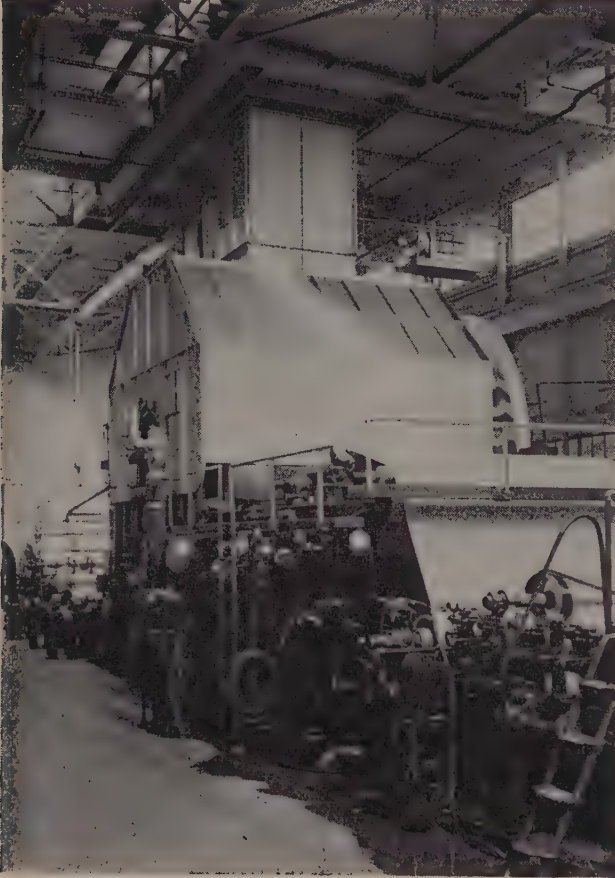


Fig. 91
Yankee Machine

Dryer felts and gears should be examined first before the dryers are "struck in" by the backtender, to make sure that repairs have been properly made and that the dryers are ready for operation.

After the dryer section is running, the steam is turned on. It is important to get the dryers up to full operating temperatures before starting the sheet over, to avoid losses due to paper coming over wet, and care should be taken to see that paper does not come over too dry.

The calender stack should be started up at the same time as the dryer section since paper can also be spoiled in putting it through a cold stack. This affects chiefly the caliper of the sheet.

The next duty of the machine crew is to engage top presses with bottom presses, run felts around slowly, while they are being thoroughly saturated with water to bring them back to their original resilience and water removal qualities. The compound leverage, which these presses are equipped with, is then adjusted in readiness to receive the sheet of paper.

The machine tender looks the wire over carefully before starting it up, engaging the clutch and moving the wire a short distance while hosing it off in the nip of the rolls so as to remove all foreign particles that might cause damage. Next, the drain on the fan pump is closed, the wire pit filled with water, the screens started and water circulated through wire pit, screens and headbox. Circulation of water is continued until the dryers and press section are ready to operate.

The machine is now ready to start. Stock at about $3\frac{1}{2}\%$ consistency from the machine chest is pumped, usually by plunger pumps, to the equalizer where the consistency is reduced and regulated to about $2\frac{1}{2}\%$ or 3% , and thence to the jordans. From the jordans, the stock flows through a regulating gate to the fan pump, then through the screens and headbox onto the wire. The machine is then in operation.

Pumps

Pumps are very important accessories to machine operation. Condensate pumps apply suction to dryer syphons and remove steam condensed in the dryers. Suction pumps apply vacuum to suction boxes, couch and press rolls. The fan pump mixes the stock from the jordan with the white water and delivers it to the machine through the Bird screens. Plunger pumps or centrifugal pumps handle white water to savealls. All of these are integral parts of machine equipment.

Equalizer

The Warner equalizer, which is widely used at Camas, was designed by Mr. Thomas Warner, one of the Corporation's oldest employees and now retired. It consists of a cylindrical tank, which the stock enters at the bottom. This consistency regulator has the advantage that it handles all of the stock rather than controlling consistency by action of a by-passed portion of the flow.

As the stock rises in the tank it is thoroughly mixed by the revolving agitator arms. On the opposite side from the agitator arms, a balanced paddle arm is supported on a ball bearing hinge bracket clamped to the vertical shaft.

The agitator and paddle arm are slowly revolved in the tank, producing a mixing action on the stock, levelling out local fluctuations of flow. The balanced paddle arm is set to a required stock resistance by means of a

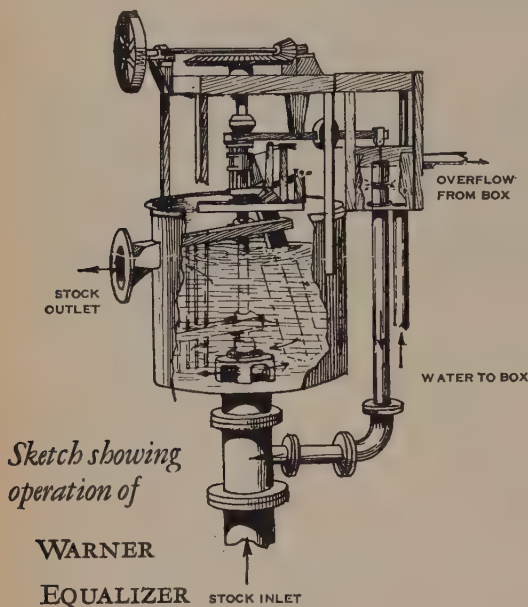


Fig. 92
Warner Equalizer

sensitive tension spring. Variations in stock density compress or expand the spring which opens or closes the water valve. Since the Warner equalizer, or any other consistency regulator can only thin the stock and not thicken it, the stock supplied to it is always kept a little on the heavy side.

Screens

From the fan pump, diluted stock passes to the screens located immediately before the headbox. Most of the screens are inward flow rotary Bird screens with slotted plates. The cylindrical screens revolve slowly, about one revolution every three minutes, and the stock is forced through the slots by a pulsating action produced by an eccentric motion of the body of the screen. The plates are cleaned once each revolution by an internal shower discharging outwardly into a waste pan.

Rejects from the Bird screen, and wash water, flow to flat screens where fiber of papermaking value is reclaimed and the rejections become a final waste.

Headbox

Much has been written and said about headbox design and many

different types have been built and operated. In fact, out of the thousand or so paper machines in this country, it is said that only fifty are duplicates

The function of the headbox and slice is to smooth out the flow and deposit a uniform level suspension of fibers on the wire. The quieter the flow, the better the control of formation on the wire. In order to accomplish this, partitions or baffles are located in the headbox, and between these, perforated rectifier rolls are submerged in the stock. These rolls have $\frac{3}{4}$ " perforations set at $1\frac{1}{4}$ " centers through which the fibers must pass. Rectifier rolls are very efficient in assisting to provide an even flow of stock to the slice.

The headbox also serves to develop a pressure head behind the slice the height of which regulates the velocity of stock leaving the slice. Fig. 3 shows the theoretical spouting velocities produced by varying heads behind the slice. By means of this diagram, the approximate head to carry for a certain machine speed can be determined. For example, at 600 F.P.M. a head of 18 inches will produce a stock velocity about equal to the surface speed of the wire. By varying this ratio between stock and wire speed, the formation and strength characteristics of the sheet can be materially changed. If the stock travels faster or slower than the wire it is known respectively as "rolling" or "dragging."

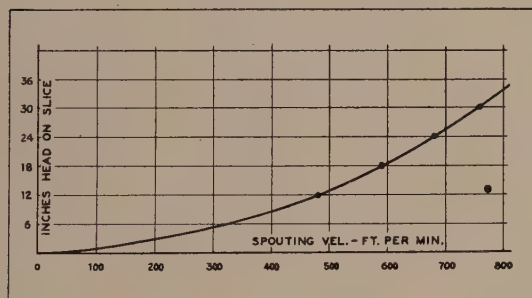


Fig. 93
Velocity of Flow
at Slice

On some machines an arrangement known as a rectifier rack is used to quiet the flow. This consists of a series of copper plates about $\frac{1}{8}$ " thick and 18 to 24 inches high spaced from one-half to one inch apart. Their purpose is to break up eddy currents and direct the stock in an even flow towards the slice.

Headboxes are often lined with copper to reduce slime growth.

Slice

The slice is essentially a dam with a variable orifice at the bottom to regulate the amount of stock flowing to the wire. Like headboxes, slices have been designed in many modified forms. The Voith with an extended

plate sloping downward to the wire and with a vertical adjustment every few inches is essentially a flexible nozzle and differs from the others in this respect.

Most of the other makes have a lip or shoe with a flexible edge that is also adjustable every few inches.

The slice is usually located over the breast roll since this roll is ground true thereby providing an even flow across the width of the slice, or over the apron board which is also level and true.

The slice regulates the volume of flow to the wire and to some extent its velocity and, by virtue of its design, controls the type of flow. Certain designs of slices, as claimed by their builders, will produce more of a "laminar" flow than others, that is where several horizontal planes will be moving at different speeds building up a sort of laminated sheet structure.

The fibers start lining up in the direction of flow just behind the slice, like logs in a stream. They travel at approximately the same speed as the water, and their alignment starts breaking up shortly after leaving the slice when the shake on the wire begins to take effect.

Adjustment of the slice is very delicate, and the general characteristics of the sheet, including tensile, tear, mullen, and formation, in addition to its basis weight, are very sensitive to small changes in slice settings.

Deckles

Deckle straps are heavy rubber belts which confine the stock while still in liquid form. A heavy deckle strap induces considerable wear on the wire which is minimized by grinding the strap to $1\frac{1}{4}" \times 1\frac{1}{2}"$ in size instead of the standard $2\frac{1}{4}" \times 2\frac{1}{4}"$ strap. Concave ground straps are essential for light weight sheets.

Some machines use no deckle straps but simply thin stationary strips of rubber resting lightly on the wire.

Shake

On practically all paper machines, mechanism is provided to shake the wire at right angles to its direction of travel so as to break up alignment of fibers produced by the spouting velocity at the slice by setting up a side to side flow.

On most machines, the breast roll is shaken which in turn shakes the wire. Some of the machines at Camas are equipped with the high speed or supershake, which shakes the side rails partway down the wire in addition to shaking the breast roll.

The super or high speed shake was originally developed to improve formation on high speed machines on the basis that stock leaving the slice

at speeds near 1000 F.P.M. was not affected by the shake until it was part way down the wire.

As a breast roll shake pivots from a point near the suction boxes its throw is greatly decreased midway between breast roll and suction boxes at which point formation improvement due to shake begins to take effect. Considerable improvement in sheet formation was therefore obtained by having the maximum shake at a point midway between the breast roll and suction boxes.

This type of shake is usually designed so that the full shake may be applied either at the breast roll, midway between the breast roll and suction boxes, or both.

Several other varieties of shakes will be found in use, including the John Lewthwaite shake, the Aldrich shake, and Bagley and Sewell 3-point shake.

The stroke of the shake varies from about $\frac{1}{8}$ to $\frac{1}{2}$ inch and the speed from 50 to 500 strokes per minute. High speed shakes run as high as 900 strokes per minute. In general, a slow stock requires a long slow stroke and a free stock a short fast shake.

Apron

The gap between the headbox and wire is bridged by an apron resting on an apron board which extends to the breast roll. The apron is usually of rubber fabric composition, thin and uniform in thickness, resistant to wear, and will lay perfectly flat.

On some machines the apron board is inclined which is a variation of usual practice. The incline is designed to produce a better control of speed of stock flow to the wire. The best results are usually secured by starting the apron just behind the slice and running out various distances on the wire, depending on machine design and grades of paper made. A long apron will naturally have more frictional drag on the wire than a short apron. Some of the faster running machines, due to a higher spouting velocity, have been able to dispense with the apron altogether.

Table Rolls

Table rolls carry the wire and the stock suspension. They assist drainage by contact with the underside of the wire. The rolls must be light in weight yet statically and dynamically balanced. Aluminum rolls will show a tendency to corrode due to electrolytic action in contact with the bronze wire, so they are covered with rubber or a composition material. Most machines, however, are still equipped with standard brass tube table rolls. The advantage claimed by the makers of some of the composition

coverings is that they carry less water around to be thrown against the under side of the wire. Camas No. 11 machine is now using several of the dandy type table rolls described in the preceding chapter.

The distance between the table rolls is important particularly on paper requiring a large volume of water. Distances vary all the way from $1\frac{1}{4}$ to 7 inches apart.

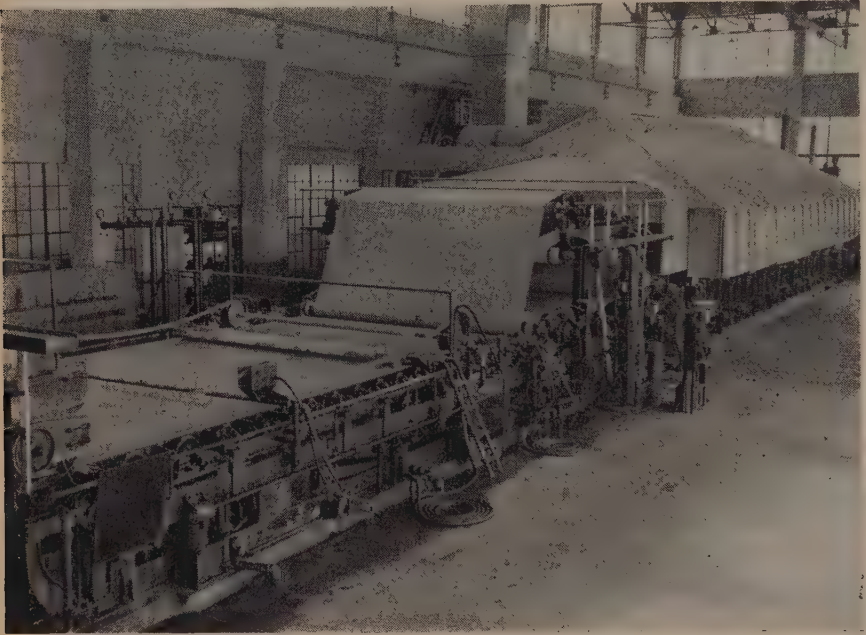


Fig. 94 Camas No. 11 Machine

Suction Boxes

At Camas practically all types of suction boxes are used from end grain maple to chromium, some slotted and others with holes of various sizes.

Suction boxes are located under the wire about three-quarters of the way from the headbox to the couch roll. Their purpose is to remove most of the water that does not drain through the wire by gravity, and to form the sheet up dry enough to carry through the press rolls. On the average about 25% of the total water is removed by the suction boxes.

The holes in suction boxes vary usually from $\frac{5}{16}$ to $\frac{9}{16}$ inches in diameter. The larger holes are necessary to remove the water rapidly on heavy papers so that sufficient jordan can be applied to control the test.

Smaller holes are used on furnishes like book, as well as slotted boxes which do not plug up so easily and streak the sheet, thus marring the formation.

If too much suction is applied, it may cause sufficient drag to "freeze" or stop the wire. To avoid this and also to avoid grooving, the boxes are oscillated slowly on about a $\frac{3}{4}$ inch stroke. There are several different types of oscillators, some have an alternating stroke with and against the travel of the wire, others move at right angles to the wire travel (that is, from back to front), and still others that are really a combination of these two. All have the same object, to prevent undue sealing of suction, scoring of boxes and wearing of the wire.

A sheet can only be brought to a certain point of dryness by suction, but beyond that suction is wasted by pulling air. A film of water between suction box and wire is necessary to minimize friction.

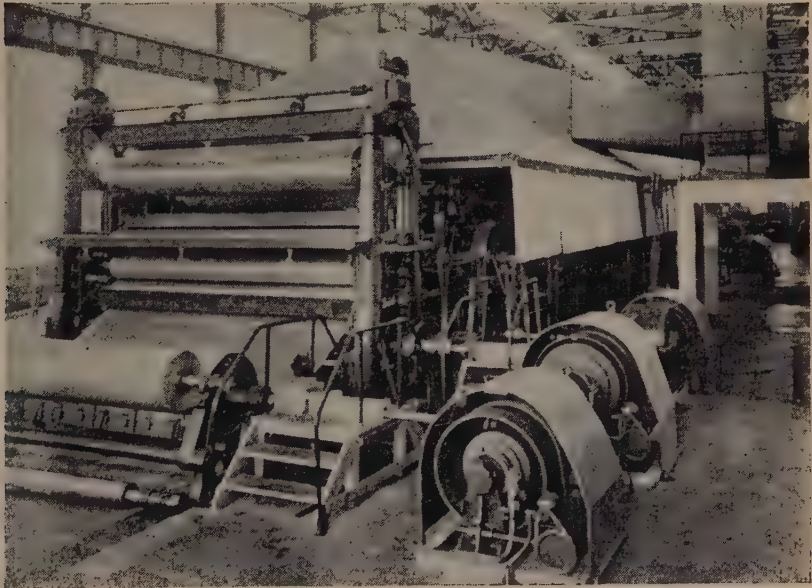


Fig. 95 . Drive Side of No. 11 Machine

Dandy Rolls

Camas, West Linn and other mills in the organization are using dandy rolls. These were formerly considered standard equipment in mills making fine papers only, but today their use has been found advantageous in the production of newsprint and there are very few newsprint mills that do not use a dandy irrespective of speed. The type of dandy usually used for newsprint is that known as the "wove" dandy. Where water marking is

desirable, "laid" and "spiral laid" dandy rolls are used and which impart the characteristic watermarked designs and lettering, etc., seen in certain grades of currency, cheque paper, legal documents, etc. These designs are first of all 'wove' or "laid," that is, sewn, brazed, or embossed on the dandy roll cover and are impressed in the sheet at the suction box area. Careful stock preparation results in good legible watermarking with correct register in the finished sheet. For papers such as news, catalog, wrapping, etc., the chief purpose of a dandy is not to produce a watermark but to help in formation by consolidating the sheet in its plastic state, and also to reduce fuzz and prevent sticking at the first press roll.

Marking of paper is also accomplished by the use of marking felts, rolls and bands. Marking felts for different striping effects are located in the press section of the paper machine. Marking rolls engage with the Yankee dryer in M. G. papers, and in the case of Fourdrinier papers the marking roll engages with one of the drying cylinders where the moisture content of sheet is the most suitable.

Rubber bands are sometimes mounted on rolls and located in the dryer section but the best results have been obtained at the smoothing press and third press where there is greater accessibility. These are usually mounted on a shaft (similar to the slitters on the top slit shaft on the winders) and with individual adjustments for each marking band. Much of the so-called watermarked paper produced today carries the mark of the rubber band rather than the dandy mark.

Machine Wire

Wires used at Camas include 60 to 80 mesh, the finer mesh usually being used on tissue machines while the coarser mesh is used in making heavy weight papers. The mesh designates the number of wire strands per inch. There are a number of different styles in weaving, some of which are the Plain Weave, the "Longcrimp," the "twill" or "basket" weave, so called by the different wire manufacturers. For certain grades of tissue, "condenser" and "cigarette" cable weaves are available.

In order to make the wire continuous, the ends are joined at the factory either by sewing or brazing. In recent years, brazing or welding of wire seams has developed to the point where the seam is practically invisible and will not mark the sheet.

Wires are made in a number of nickel, brass and copper alloys, phosphor bronze and stainless steel, depending on the specific application. Stainless steel wires, it is believed, are still in the experimental stage since they tend to "work harden" in use, thus becoming brittle. Bronze wires are advantageously used where an acid condition exists.

Many factors contribute to short wire life, among which may be mentioned excessive wire tension, improperly fitting doctors on the first wire return roll and breast roll, load on the wire at apron and breast roll, method of oscillating suction boxes, lubrication between boxes and wire, type of suction box covers, size and spacing of suction box perforations or slots, and undue bending or flexing of the wire in its travel around the stretch rolls.

To get some idea of the load exerted on the wire by suction boxes, consider that seven boxes, 187 inches by 8 inches, under a vacuum of 10 inches, exert a pull on the wire of $21\frac{1}{2}$ tons.

The following table, compiled by a prominent wire manufacturer, is of interest in showing the drainage characteristics of wires of different mesh.

Mesh	Openings per Square Inch	Theoretical Open Area
0		100.0%
60	2,242	26.9%
65	2,860	25.7%
70	3,360	26.7%
75	3,900	25.8%
80	4,480	27.0%

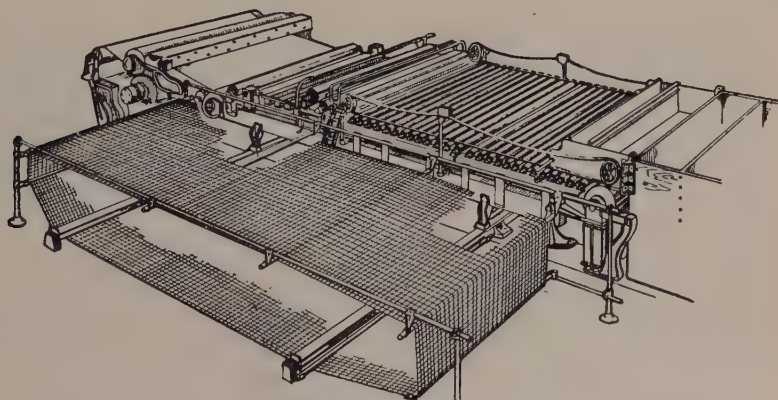


Fig. 96. Beloit Removable Fourdrinier

Wires are changed most effectively with what is known as a removable Fourdrinier. The wire is strung in the aisle while the machine is in operation, by removing it from its box and looping it on a special carriage as shown in Fig. 96. The machine is then stopped, the old wire removed, and the entire table roll section rolled out into the aisle on rails. The wire is

quickly strung in place and the entire unit rolled back into place ready to resume operation.

Wire Guides

To prevent the wire "creeping" too far toward one side of the machine or the other, automatic wire guides are used, replacing the old method of guiding the wire by manual control. The usual type consists of oscillating plates against which the wire bears when it starts running off and which are connected to a ratchet arrangement that moves the ends of the guide roll back or ahead to correct the side motion of the wire. The Voith wire guide has no mechanical parts touching the wire. A needle-like jet of water is centered over a small opening to a pump that moves the guide roll bearing when the water jet is off-centered.

Suction Couch

The jacketed top and bottom couch rolls are being generally replaced by suction couch rolls from which the sheet is transferred to the first press section.

A suction couch consists of a drilled bronze cylindrical shell, with internal suction box having a sealing strip on each edge and adjustable stops to confine the suction area within desired limits so that the only air entering the couch roll must pass through the sheet on the wire.

The suction couch distributes the suction over a relatively large area instead of confining pressure to a nip, as in top and bottom couch rolls, and which may disturb the fiber formation. Unless properly handled, however, a suction couch may produce a two-sided sheet and may cause shell marks. Some papermakers still prefer the jacket couch for finer grades.

The size of perforation depends on the grade of paper made. News machines use a large hole, $\frac{1}{2}$ " x $\frac{5}{8}$ " concave, but the average is $\frac{1}{4}$ " x $\frac{1}{2}$ " concave.

The suction couch drives the wire, and since it turns with the wire, it does not exert the frictional drag typical of flat suction boxes. It has been estimated that 80% of wire wear occurs at the suction boxes and only 5% due to slippage at the suction couch.

Presses

On leaving the wire the wet sheet is carried on felts through two, three or four sets of press rolls, the purpose of which is water removal. Effort is made to remove as much water as possible in the press section since evaporation of the water by steam in the dryers is more expensive than pressing. The limiting factor in mechanical water removal in presses

is the point where loading of the rolls causes "crushing" of the sheet.

Probably the most important recent advance in press roll design is the suction press of which there are two types, the metal suction roll with rubber top roll, and the perforated rubber covered bottom roll with metal or granite top roll. Of the two, the rubber suction roll is the more efficient. A metal top roll cannot be used on a metal bottom suction roll as the action is too severe on felts.

Rubber suction rolls have a brass shell $\frac{3}{4}$ " to 1" thick drilled with $\frac{3}{16}$ " holes at $\frac{5}{8}$ " centers, overlaid by rubber about $\frac{3}{4}$ " to 1" thick perforated with $\frac{1}{8}$ " holes. The holes in the rubber tend to close up in the nip producing less marking of the sheet, yet the roll is effective since the water is removed just before the sheet enters the nip. This type of roll has two outstanding advantages, less wear on felts and better water removal. In many instances the savings in steam and felt life alone are sufficient to pay for the cost of the installation in a short time. Since the water is removed with less nip pressure, the felts are kept cleaner and drier and more bulk is given to the sheet.

On machines making higher grade papers smoothing rolls are used just before the sheet enters the driers. Their purpose is to iron out the sheet and give the top side a smooth surface. Usually a chilled iron roll is used on the bottom with a 60 plasticity rubber roll on top.

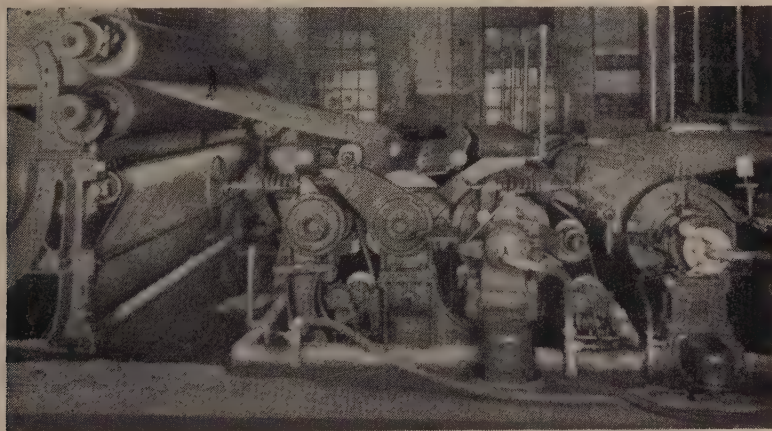


Fig. 97 Beloit Horizontal Dual Press

A recent improvement in press rolls is the Beloit horizontal dual press in which three press rolls are mounted side by side and the pressure regulated by heavy springs, or hydraulic cylinders. It is claimed that this

installation produces a drier and smoother sheet with less felt wear than top and bottom presses.

Wet Felts

A paper machine has two sets of felts, the wet felts which carry the sheet through the press rolls and the dryer felts which carry the paper web through the dryer section.

Suction boxes are often used on wet felts to keep them open and remove excess water from the felt. It has been found that chromium plated covers in these boxes will materially increase felt life if the felt is not too dry.

It is important to keep a felt running straight so that maximum efficiency and life are obtained. To assist in this, the manufacturers weave a marker strip into the felt so that it is easy to see if one edge is getting ahead of the other, or if the center is getting ahead of the edges which often happens due to the effect of crown in the press rolls.

As a felt wears and becomes filled, it loses efficiency in drainage which has to be overcome by increased steam usage in the dryers. Eventually a point is reached where steam costs overbalance felt costs so that the total cost of water removal begins to go up. When this point is reached it becomes a matter of economy to replace the felt.

The life of felts is affected considerably by water conditions. For example, iron in the water may become precipitated in the felt as iron hydroxide, making it stiff and "boardy" before it has become sufficiently worn to justify removal. The result is that the felt is unable to handle the water fast enough and crushing of the sheet occurs.

Felts contain a certain amount of wool fat and hence are hard to wet immediately with water. This involves a certain "breaking in" period and to hold this to a certain minimum, wetting-out agents are used

An open felt will give a high drainage rate but may mark the sheet. Conversely, a fine felt will provide the best finish to the sheet, but is able to handle limited quantities of water. In selecting a felt for a job a balance must be maintained between these two opposing factors.

Dryers

From the presses the sheet passes to the dryers at about 65% to 70% moisture content. It is important here, as elsewhere on the machines, to have the draw carefully adjusted. Actual tests have shown that comparatively small changes in draw have produced a 30% change in tensile strength. The driving mechanism, discussed in another chapter, is so arranged to take up the machine direction expansion of the sheet as it dries, and thereby maintain a constant tension or draw.

Dryers are cast iron cylinders with about 1" to 1½" walls, machined inside and out. The heads are usually cast iron also, but in recent installations steel heads have been provided by the paper machine manufacturers.

Condensate lines and dryers are occasionally washed out with soda ash solution to remove oil. An oil film inside the dryer interferes with heat transfer through the shell and clogs exhaust lines from the dryer if allowed to accumulate. This condition is peculiar to those machines driven by steam engines and using the exhaust steam discharged from the engine for drying.

The admission of steam to machine dryers, also the removal of condensate from the dryers is made through a hollow trunnion, using a special packing joint to prevent leakage as the dryer revolves. Internal syphon pipes or bucket evacuators are used for the removal of the condensate. Fig. 98 shows a dryer packing joint with steam admission pipe and condensate removing pipe, also the dryer syphon pipe within the dryer. The dryer syphon pipe does not revolve with the dryer and is bent so that it almost comes in contact with the lower part of the dryer shell to make the evacuation of condensate as complete as possible.

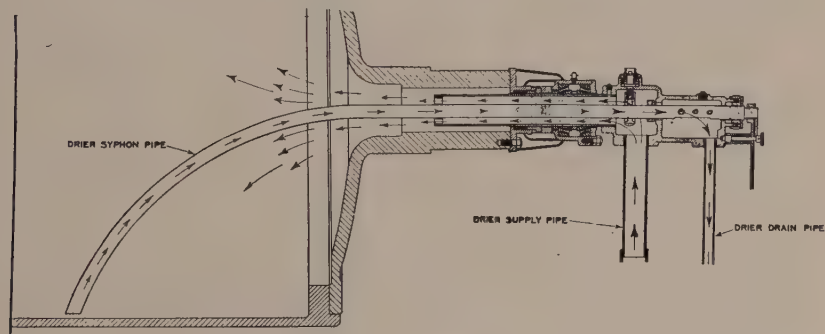


Fig. 98 A Dryer Condensate Removal System

Evacuator buckets or dippers are fastened to the internal surface of the shell and rotate with the dryer, picking up a definite amount of condensate at each revolution and discharging same into the trunnion pipe when the dipper reaches a sufficient elevation above the trunnion so that the condensate flows from the dipper or bucket by gravity.

On paper machines in which all of the dryers receive their steam from a common steam header and lead the condensate to a common header such a layout is called a single header system.

The present day practice on large machines is to sectionalize the header into two or more sections. On the two section header approximately 85% of the dryers (generally starting from the dry end of the machine) are

connected to the high pressure steam header. The condensate from these dryers is removed into a condensate header and flows into a flash receiver. A small amount of steam which is sometimes allowed to circulate through the high pressure dryers also accumulates in this flash receiving tank. The vapor from the flash receiver tank forms the steam supply to the dryers in the low pressure section and generally a differential valve for admitting steam from the high pressure header is installed, should the flash steam fail to meet the requirements of the low pressure dryers. In general, there is a three or four pound pressure differential between the high and the low pressure section. Condensate which accumulates in a flash receiver is drained off under float control to the condensate pump. A separate condensate header is used for the low pressure dryer section. This header discharges directly to the condensate pump.

There are many different sectional header systems on the market, such as the Fulton, Stickles, Penberthy, and the Cram, some of which use individual traps on each of the dryers in the low pressure section. Fundamentally, all systems operate alike and are designed on the basis that since

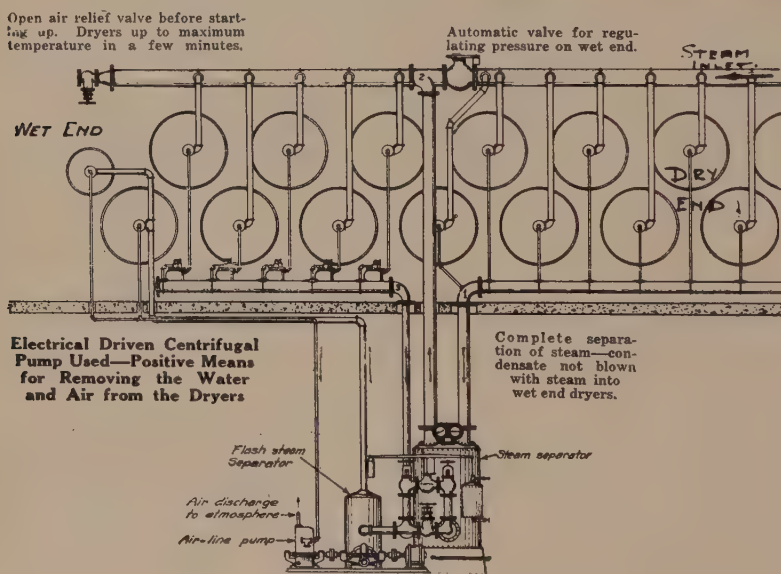


Fig. 99 Fulton Sectional Header System

they allow some steam to circulate through with the condensate from the high pressure dryers, there is a lesser possibility of air accumulating in these dryers. In general, the condensate pumps are designed to handle both air and condensate and by the use of cold water sprays they may be operated under a partial vacuum.

The rate of condensation of the individual dryers in a section will vary over a wide range, the dryers in the wet end section condensing a much larger amount of steam than those in the dry end section. Tests on small machines with a total of 23 dryers show that the first five dryers from the wet end condense steam at the rate of 1200 pounds per hour each, whereas the average for the last five dryers at the dry end section was approximately 250 pounds of steam per hour. In view of this condition, some of the steam and condensate systems advocate the use of graduated orifices in the condensate pipe in the individual dryers to prevent a surplus of steam from going through, but such systems can only be applied to machines operating continually on a definite basis weight of paper and at constant speeds.

In order to utilize all of the heat possible in the steam supplied to the paper machine, numerous machines are equipped with air heaters, the hot condensate from the machine being pumped through the heater tubes and air is forced around the tubes. The heated air from such an arrangement is often used in the dryer felt pits to assist in the removal of the moisture from the paper.

On machines making creped papers it is sometimes desirable to use high pressure steam on the first one or two dryers on the wet end, in order to set the crepe.

In the drying of papers, there is generally some specified end point in respect to moisture content of the finished sheet which it is desirable to maintain. Uniformity of this requirement has lead to the general use of some automatic control system to eliminate the human element in this factor. Controlled systems may be of the pressure, temperature, or moisture content type.

The pressure control systems may be hydraulically or air operated, and are designed to maintain a definite steam pressure within the dryer header.

Automatic temperature control systems are generally of the air operated type. The thermal element may be installed either through the trunnion of a specified dryer, in the steam riser to that dryer, or in the steam header itself. Automatic moisture controls have been designed operating on widely different principles. The Stickles steam regulator for moisture control consists of a tension roll in contact with the paper. This roll is usually located between the second and third dryer from the dry end of the machine. With an increase or decrease in moisture content allowing the paper to be stretched more or less, this roll which rides the paper assumes a different position for dry and wet conditions. The motion of the roll is mechanically transferred to a pilot valve which admits water to an operating cylinder. This in turn controls the admission of steam to the

dryer section.

A later and much more elaborate piece of equipment for moisture control called the Verigraph operates on an entirely different principle

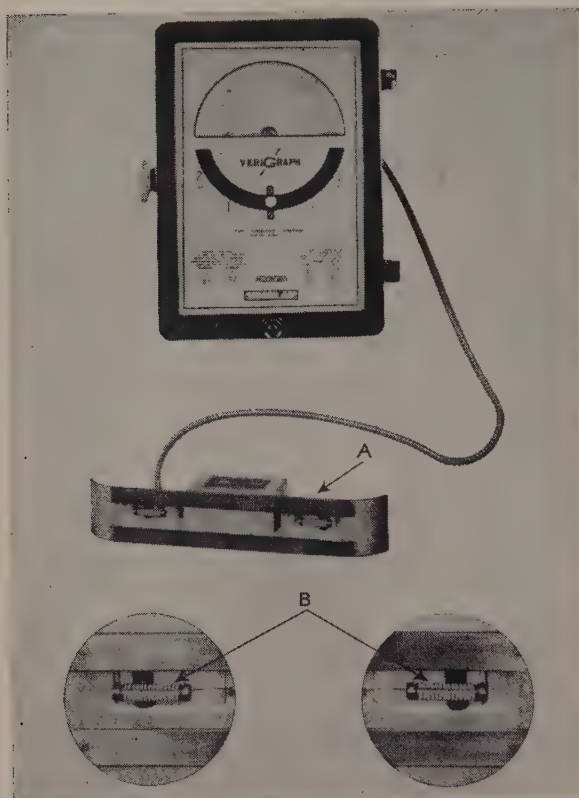


Fig. 100
Foxboro Verigraph

The controlling element of the Verigraph consists of a metal shoe in contact with a sheet of paper and preferably located between the first and second dryer from the dry end. This shoe contains two recesses in which are mounted condensers in a high frequency electrical circuit. These condensers are made of a hygroscopic material and thus the condenser capacity varies with the moisture content of the sheet of paper passing over the shoe. Changes in condenser capacity are amplified and the impulses transferred to a circuit of normal frequency and relays are used to reset an air operated temperature controller, this in turn admits more or less steam to the dryer section as conditions require.

The dryer sections of paper machines are generally covered with hoods of insulated material equipped with ventilating stacks to collect and

remove from the machine room the vapors formed by the moisture from the sheet of paper. The maintenance of definite air conditions surrounding the dryers and the removal of the vapor from the dryer section is a phase of the operation equally important as that of admitting steam and removing condensate from the dryers themselves. A casual inspection of a dryer section in operation, especially on a large, high speed machine, will show quite definitely that the maintenance of uniform air conditions surrounding the dryers is a difficult problem.

The rotating dryers themselves cause definite eddy currents and the numerous layers of dryer felts impede the travel of the vapor to the stack. As a result of this condition, the machine using natural circulation will tend to produce a sheet which is drier on the front and back edges, the higher moisture content at the center of the sheet being due to the pocketing of vapors in this zone. This condition generally results in overdrying the front and back edges of a sheet of paper in order to obtain the desired moisture content in the center of the sheet. In order to correct this condition hot air systems are sometimes used.

The Ross-Grewin system uses a positive pressure blower and air heater. The hot air being discharged through nozzles mounted at a reasonably high velocity is carried through to the center zone eliminating the dead pockets at this point and resulting in much more uniform drying across the sheet of paper. Such equipment is especially desirable on machines in excess of 200 inches in width.

On pulp drying machines, where there is little possibility of a plug up due to the paper breaking in the dryer section, low pressure hot air systems are used, the air being discharged from nozzles across the entire width of the sheet, and on Yankee machines making machine glazed products a double hood is sometimes used which enables heated air to be discharged through nozzles over the entire face of the sheet of paper as it is in contact with the dryer.

The stacks which remove the accumulated vapors from the hood will generally extend out through the roof of the machine room and discharge to the atmosphere. On modern machines these stacks are equipped with variable speed fans to control the amount of air removed with the vapors.

In certain sections of the country where extremely cold weather conditions exist, economizers are installed to make use of the heat in the vapor removed from the dryer section of the paper machine to heat the incoming air. The expense of such an installation can only be justified where the temperature range is extreme.

Dryer Felts

Cotton triplex dryer felts are used at Camas for standard equipment.

Some experience has been had with asbestos felts. The purpose of dryer felts is to hold the sheet firmly against the dryer shell so as to secure maximum heat transfer from dryer to paper and produce a smooth surface. On machines running very heavy grades of paper, also on pulp and board machines, no dryer felt is used.

Dryer felts are about five times stronger than plain wet felts. In order to secure good drying, dryer felts must be kept in tension and arrangements are installed to automatically control the tension at about two pounds per inch width of dryer felt.

A machine has two or more dryer felts, depending upon the division of the dryer cylinders. Half of these are on the top dryers and half on the bottom series of dryers. They are kept in proper alignment by an efficient automatic felt guide.

Breaker Stack

On some machines, breaker stacks or nip rolls consisting of two steel rolls, are installed in the dryer section where the sheet contains about 35% moisture and by thus providing a mild calendering action on the wet paper produce a compacting smoothing effect.

Calenders

Finish is applied to paper by passing it through a series of chilled iron rolls. Only the bottom roll is driven so that there is some slippage between adjacent rolls, producing an "ironing" action on the sheet.

On account of the weight of the stack, the bottom calender rolls must be accurately ground. Some of the rolls are drilled for steam in order to develop the desired gloss on highly finished papers.

Sometimes difficulty is experienced due to local overheating and expansion at some point in the stack. This produces uneven caliper and buckles and is corrected by blowing cold air on the stack at that point, and by disengaging doctors from rolls.

Supercalenders

Supercalendering is a separate operation from the paper machine, and resorted to where a higher gloss is desirable without blackening. The supercalender is similar in principle to the paper machine calenders. However, part of the rolls used are fiber instead of steel or iron. These fiber rolls are constructed of special material for special uses. Wool, cotton and asbestos materials are used, the latter claimed to be the best for glassine, where higher pressure and temperatures are employed. A supercalendered

finish is specified for certain grades of book, cover, transparent waxing stocks and glassine.

Fiber rolls are alternated with metal rolls which are bored for steam. It is this arrangement that differentiates it from the machine calendering operation, imparting a more permanent finish without undue crushing of fiber.

Winders

The web is rewound into finished rolls of suitable size on winders, usually installed with a maximum speed three times that of the paper machine. For example, the Cameron winder on Camas No. 5 machine can be operated at 2250 feet per minute.

The operation of a winder is very important as the saleability of a good sheet of paper can be spoiled by poor rolls. Uniform tension is necessary to avoid weaving and starring. On slitting jumbo rolls it is often difficult to maintain uniform hardness in all rolls due to variation in caliper across the web. Much depends on the skill of the backtender in building a good reel first and then on the skill of the winderman to produce good rolls from it.

Machine Production

As a matter of general interest, the actual production of a paper machine may be calculated as follows:

$$\text{Production per hour} = \frac{\text{Inches trim} \times \text{F.P.M.} \times \text{Basis Weight}}{576}$$

Creped Papers

Some grades of napkin, toilet, towel and fruit tissue are semi-creped on the paper machine, with from 5% to 15% stretch or crepe, but where a higher degree of stretch or crepe is desirable, the additional operation on a creping machine is necessary producing "full crepe" or "two process" crepe. The Camas creping machine is 130 inches wide with four 48" x 130" dryers and is driven by a 30 H.P. motor with a Ward-Leonard control. The machine handles basis weights from 11 pounds to 80 pounds per ream. The actual creping is done with a doctor blade against a steam heated steel roll rotating in a water bath on which rides a soft rubber roll. The machine operates at speeds up to 475 feet per minute and produces from 25% stretch in toilet and napkin to 35% or more in other grades.

Laminating

Camas mill has a 76" Waldron laminating machine with 14" coating

rolls and two 48" x 76" cooling rolls. This machine combines two sheets of paper with asphalt, producing a large variety of weights and coatings. Paper products of this type are used for bags, building paper, car liners, egg crate liner, newsprint and waxing roll wraps and for many other uses.

Capacity of the machine is about 2000 pounds per hour. The asphalt is melted in a tank of 60 barrel capacity equipped with a thermostatically controlled steam coil heating system. Temperature in the tank is maintained at 330° F. Pumps, pipe lines and machine pan are all steam jacketed. The machine is illustrated in Fig. 101

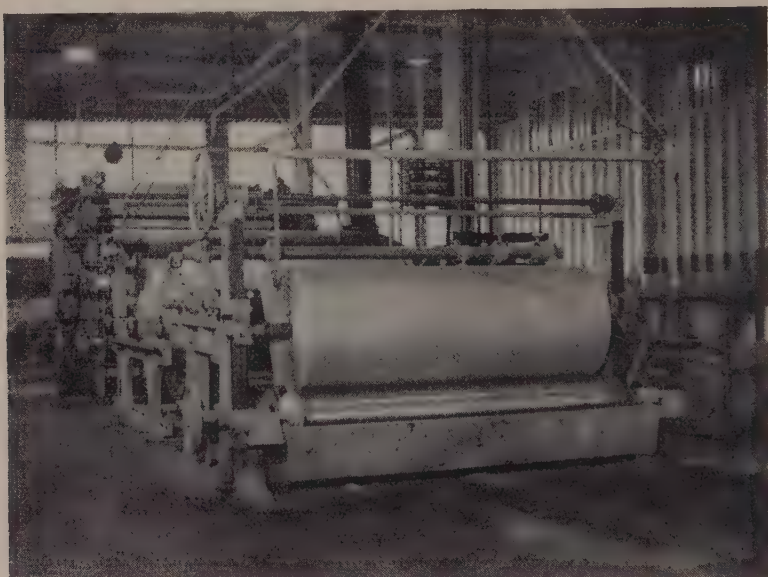


Fig. 101 Asphalt Laminating Machine

In compiling this chapter attention has been given mostly to description of equipment at Camas. For a broader and more detailed description of paper machine construction and operation in general, reference should be made to Volume V of the series *Manufacture of Pulp and Paper*.

CHAPTER XV

PULP DRYING

By F. R. SIEVERS

In the early days of the industry, paper mills were usually built close to their supply of principal raw materials. Mills using wood pulp were built close to forests where the proper wood could be obtained for their pulp supply. As these forests were depleted, many mills found themselves either shipping wood from long distances or buying pulp from mills which still had a supply of timber. This development of a pulp market led to the building of mills designed to produce pulp alone. This pulp is often produced at great distances from the mills which manufacture the paper and is shipped by rail or water. As freight rates take a great deal of profit from the pulp producer, it is necessary to ship the pulp at as low a moisture content as possible.

The problem of getting pulp dried to an economic level was met by manufacturers and engineers with the development of modern pulp drying machines. The three most outstanding developments in pulp drying equipment are: the Flakt Dryer, the Minton Dryer, and the ordinary type of drying rolls in combination either with a cylinder or Fourdrinier wet end.

The Flakt Dryer

The Flakt system of drying pulp was developed in Sweden. The dryer as furnished complete from its makers consists of a Fourdrinier wet end, pre-dryers and a drying chamber where the pulp is dried by radiation and the flow of heated air without extensive contact with metal surfaces. It is claimed that this feature produces pulp of brighter color, better strength and easier re-pulping quality than pulp dried on conventional dryer cylinders where overheating of surface fibers may occur.

The wet end of the Flakt machine differs from the ordinary paper machine in the respect that two presses are mounted over the suction couch, one of these being a hard rubber roll with grooves about four to the inch and the other a smooth press roll of medium density rubber.

In the travel of the sheet through the Flakt dryer, the pulp flows from a headbox to the wire which is equipped with suction boxes, similar to the ones used on paper machines. The pulp mat passes over the couch roll at the end of the wire where it is pressed first by the grooved rubber roll,

then by the smooth rubber roll, both of which run in contact with the couch roll. From the wire the sheet passes to a felt which carries it through a press in the same manner as on a regular paper machine. It is then passed over two dryer cylinders known as pre-dryers, the purpose of which is to heat the pulp, thereby reducing the viscosity of the water still contained in the sheet so that it may be more easily removed as it passes through two more heavily weighted presses before entering the dryer chamber. Hot water is sometimes sprayed on the pulp as it passes down the wire to accelerate, in a similar manner, removal of water at the suction boxes and suction couch. However, there is a limit to the temperature to which the sheet can be raised before entering the dryer as the web breaks more easily when hot. This limit is reached when the sheet becomes so weak in strength that it will not pass through the drying section without breaking. In both the Minton and Flakt dryers this critical point is about 100° F.

The dryer section in the Flakt machine consists of an enclosed drying chamber from 100 to 200 feet long, of varying widths and from 16 to 20 feet in height. The roof, bottom and sides are entirely enclosed with sheet iron and well insulated. The gables, or inlet and outlet ends, are equipped with revolving windows.

The pulp web passes back and forth inside the Flakt dryer many times and hot air is constantly blown against both sides of the sheet.

Adjustable platforms are located at the inlet and outlet ends of the drying chamber. These platforms are located at these points to allow the operators to start the machine and are adjustable vertically by manually operated controls. A number of conveyors are provided for carrying the pulp sheet through the machine. These are constructed of forged steel chains furnished with rolls and tubes for carrying the web. The chain drives run on guide rails at the sides of the dryer. Inside the dryer are batteries of heating coils to maintain the air in the dryer at operating temperatures.

The air discharged from the dryer is passed through a heat exchanger to warm the incoming air and, with this equipment, heat losses are very low.

The pulp in both entering and leaving the dryer passes through small sealing rolls; thus the dryer section becomes a more or less hermetically sealed room. This is done so that no outside cold air currents may enter and interfere with the uniform drying of the pulp.

The pulp after leaving the dryer is cut into sheets on a standard cutter. The dried pulp sheets are stacked in bundles of about 450 pounds each and run into a hydraulic press where from 100 to 200 tons pressure is applied and which reduces the bundle to about two-thirds its original size. The

bundles, or bales, are wrapped with pulp sheets and tied with wire or iron straps by means of a patented tying machine. Each bale is stenciled with the name of the consignee and usually marked and numbered so that it can be traced back through the mill to the digester and number of cook from which the pulp originated.

Minton Dryer

In the Minton dryer, the forming end of the dryer may be either the cylinder or Fourdrinier type. Hot water is sprayed on the pulp while the sheet is being formed and pre-dryers are used the same as in the Flakt dryer.

The outstanding feature of the Minton machine is the fact that the pulp is dried in a partial vacuum. Water will boil at 212° F. in the open air but water in a partial vacuum will vaporize at lower temperatures. In the Minton dryer enough vacuum is maintained that the water will rapidly leave the pulp at around 130° to 140° F.

The drying section of the Minton machine comprises steam-heated rolls similar to the conventional paper machine drying section except that they are completely enclosed in an airtight sheet metal housing. At each end of the dryer are located rubber sealing rolls through which the pulp web enters and leaves the dryers. Inside the housing the web is carried through by the usual type of backtender ropes. Doors are provided in the housing so that in case of a break the crew may enter the dryer section to remove the broke. The pulp, when dried, is cut into sheets, baled and finished in the same manner as is done with the Flakt system.

Kamyr Machine

The Kamyr machine at Camas is run on special pulp made from selected wood which is cooked in digesters specially allocated to produce this pulp. After the pulp is washed it is pumped from a storage tank through screens, over deckers and finally sent to a white tile-lined chest where it is kept in rapid agitation with Witham circulating propellers. From this chest the washed and thickened pulp is pumped to the Kamyr machine headbox. All the rejects from the screens are reclaimed and diverted into the regular mill stock.

From the headbox there is an overflow back to the pulp chest. There is also a gate located in the bottom of the headbox which opens into the mixing box where the pulp is mixed with water to be fed to the sheet-forming cylinder. This is a sliding gate constructed of bronze and the top and bottom sections rounded so that there are no square corners to clog up or retard the smooth flow of stock to the mixing chamber.

As the pulp flows into the mixing chamber either filtered water, or

return water from the forming cylinder, is added so that the pulp will enter the machine at between 0.3% and 0.5% consistency.

From the mixing chamber the pulp flows into a second headbox specially constructed with three compartments to distribute the flow of pulp evenly across the width of the machine. The pulp then flows into a deep section of the box, under a baffle, and over a rectifier that evens out the flow as it enters the vat in which is located the forming cylinder.

The forming cylinder is constructed on a cast iron core with iron fins about 1" in thickness extending radially from its axis to a common circumference, and running longitudinally the full length of the core. One end of the casting forms a web about 1" thick that seals the entire end and in appearance this casting is constructed much the same as the paddle wheel on a river steamer.

The core is about 6 feet in diameter and 9 feet in length. It has been carefully turned in a lathe, so by placing a sheet of perforated bronze around its circumference, a perfect cylinder is formed. This makes a very simple and rugged cylinder mold. The mold is mounted horizontally on a shaft through its central axis, and rests in a steel semi-circular vat which allows a submersion of about three-quarters of its diameter and provides a clearance of about one foot between vat and cylinder.

The casting at the back or closed end of the vat is a plain wall serving no other purpose than to support the cylinder shaft bearing and keep the pulp suspension in the vat.

The front end casting is more complex. From this end of the cylinder the water and air are discharged from the pulp sheet. The inner wall of the front end of the vat is a cast wall having three openings in it, one for discharge of water and air, one to regulate the stock in the vat, and one which is connected to the outside atmosphere so that the sheet can be released from the cylinder when formed.

The first two openings mentioned discharge into a hermetically sealed receiving chamber nearly the full diameter of the cylinder end and about one foot in depth. From the bottom part of this chamber a 12" water leg extends down into the basement. The outlet of the water leg is submerged so that no air can enter it and the water flowing down through this pipe helps form a suction in the cylinder.

In the top of the receiving chamber is located a six inch riser connected to a Hytor vacuum pump which draws out most of the air entering the inside of the cylinder through the pulp sheet as it is being formed on the face of the cylinder.

The end of the fins forming the compartments in the cylinder are

squarely machined and are held tightly against the inner wall of the front end by a large coil spring encircling the shaft as it extends out beyond the front end bearing.

To prevent the ends of the cylinder and the inner wall of the vat from wearing away rapidly the manufacturers have designed a rather unique thrust bearing. This is formed by a circular indentation of the central core of the mold, forming a closed circular chamber, through which the shaft passes, and which is sealed by packing glands. Into this space water is forced under pressure and, as it cannot escape, it forces the cylinder toward the back end of the vat. In this manner, by proper manipulation of pressure in this chamber, a balance is formed between the thrust of the water pressure and the pull of the coil spring on the end of the shaft, so that, while the ends of the cylinder fins are drawn far enough ahead to seal, they are held back to prevent undue wear and excess friction load as the cylinder turns.

The cylinder is driven from a main shaft by cone pulleys and gears. The cone pulleys are necessary so that the speed may be changed, as different weights of sheets and varying freeness of the pulp require different cylinder speeds.

A special facing wire is used on the cylinder. It is what is known as the "twisted strand" type of construction, each strand being made up of many fine wires in the same manner that a wire cable is made. This makes a wire that is very strong and will stand very hard usage. The mesh size is equal to about a 30 mesh plain wire. The facing wire is placed tightly around the outside of the cylinder and joined either by sewing or welding. The wire must be smooth and tightly fitted as any looseness of the facing wire will distort the sheet and cause it to break or wrinkle.

Sealing straps are used on both ends of the cylinder in the same manner as on the conventional decker or wet machine, the exception being that in the web casting supporting the sealing strap on the front end of the cylinder, there is a groove into which water is forced under pressure to insure a minimum of friction and a more positive seal so that pulp will not leak out of the cylinder into the white water.

On the top outside face of the cylinder are mounted two grooved rubber press rolls covered with a 10 mesh facing wire. These rolls are pressed tightly against the pulp sheet as it is carried on the face of the cylinder and the wire covering prevents them from picking up the sheet from the cylinder face.

A third roll is carried on the cylinder on the side where the sheet leaves to enter the press. It is made of soft rubber and acts as a couch roll that aids in removing the sheet from the cylinder when it is formed.

Operation of the Kamyr Machine

Due to the fact that free chemical pulps separate easily from water there must be rapid circulation, or agitation, of stock in the vat. Efficient circulation gives a good even sheet, while poor circulation forms a lumpy uneven sheet.

The sheet is formed by the water being drawn through the facing wire on the cylinder leaving the pulp adhering to the wire. Since the wire is covered with pulp and water is flowing through the water leg while the vacuum pump is pulling out the air from the receiving chamber at the front end of the vat, a vacuum is formed inside the cylinder. A vacuum of from 9 to 10 inches is maintained in normal operation.

As the sheet passes over the top of the cylinder, the wire covered rolls press out more water and harden the sheet so that it can be more easily handled on its way to the press.

Hot water sprayed on each press roll and on the pulp sheet performs a two-fold mission. It keeps the rolls clean and decreases the viscosity of the water in the sheet so that it can be more readily removed.

Press Section

The press rolls on the Kamyr machine are cast from a special iron alloy and differ considerably in design from the press sections of paper machines. No felts are used, the design of the press being such that an unsupported pulp sheet will carry through without breaking or crushing. This is due to the fact that both top and bottom rolls are turned with fine grooves cut in the face of the rolls.

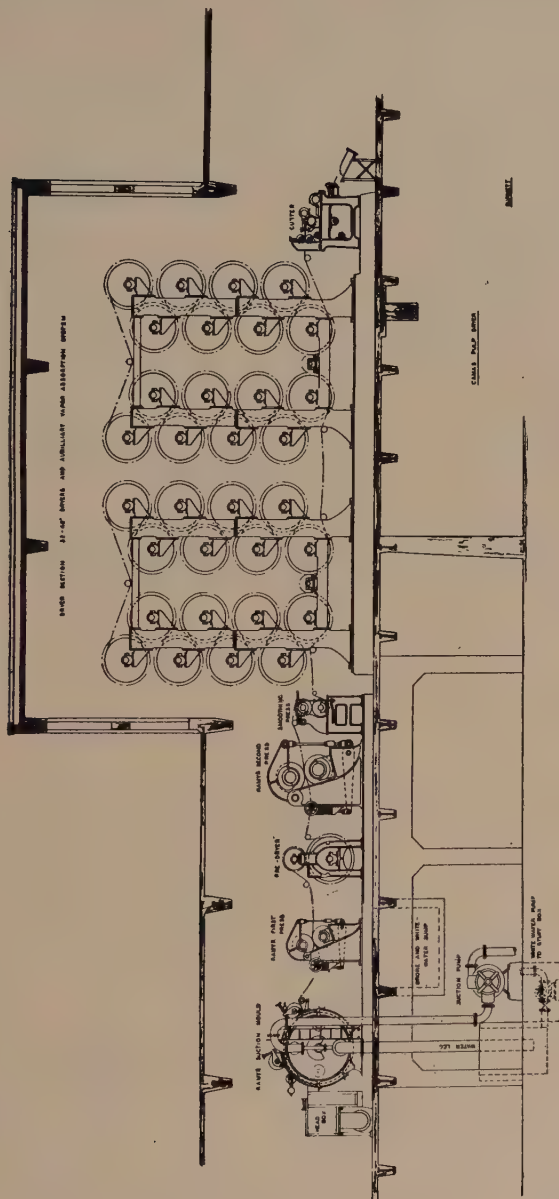
The grooves on the first press are four to the inch, the rib between the groove being $\frac{1}{8}$ " and the groove of equal width. The depth of the groove is not so important except that it must be deep enough to take up distortion of the sheet when it is pressed. The sheet is firmly held by the grooves in the roll and cannot spread apart or "crush."

To facilitate removal of the water, a "water doctor" rides on top of the sheet carrying off the water from the upper sheet surface. On the bottom surface a small adjustable roll holds the sheet away from the press so that the water expressed at this point can flow down the face of the press roll to the water pan.

A combination of lever and spring type of mechanism is used to control the amount of weight carried on the presses. It is very ruggedly built and it is possible to obtain up to 70 tons per square inch pressure on the sheet at the nip of the press rolls.

Two presses of the type described are used. The second press has seven

grooves to the inch instead of four and the rolls are twice the diameter of the rolls in the first press.



it travels over two dryer cylinders which heat the sheet and by reducing the viscosity of the water, greatly improves the efficiency of water removal in the second press.

In the first press the sheet contains enough water to be weak or tender and care must be used in regulating the pressure applied at the nip. In the second press, however, the limit to the amount of pressure that can be applied is simply the mechanical strength of the press, providing, of course, that the sheet is even. Tests taken on pulp leaving the second press show about 50% bone dry stock.

After the pulp sheet leaves the second press its surface has the appearance of coarse corduroy cloth. In drying a sheet of paper, the more tightly and evenly it is pressed against the dryer surface, the more rapid will be the heat transfer and consequently the more efficient the drying operation per square foot of dryer area. Accordingly, to smooth down the sheet after leaving the second press, it is passed through a smoothing press to iron down the ridges. This is the only function of the smoothing press.

Dryer Section

The dryer section of the Kamyr machine is made up of 32 dryers arranged in four sections, the machine being four dryers high instead of the conventional two dryers high as on the paper machines. This type of installation is called stack dryers, the main advantage being the saving in floor space.

The pulp web is carried through the dryer section with a Sheahan rope backtender. The dryers are 48" diameter and 113" face. No dryer felts are necessary.

Steam is controlled by a hand operated valve from a 30-lb. (maximum) supply line. The dryer steam system is divided into sections so as to provide for graduated temperatures on the dryer sections if desired.

The pulp enters the dryers about 55% air dry and leaves them about 90% air dry. On this type of machine a heavy sheet is more adaptable than a light sheet so the basis weight of the sheet is held from 550 to 1000 lbs. on a 480 sheet count. Exact control of basis weight is not, of course, of the same order of importance as in making paper.

The moist air is drawn from the dryer section by a fan. A separate fan and heater are installed to blow hot air on the surface of the sheet and force the moisture from pockets formed by the peculiar construction of the stack dryers.

When the sheet is dry it is run through a cutter equipped with a slitter arrangement. The sheet enters the slitters and is cut in strips 26" wide, then through a fly knife the full width of the machine which cuts the strips

into 32" lengths. This gives a sheet of 26" x 32" as a standard size.

The cutter is similar to the type generally used on Flakt and Minton dryers and is more or less standard equipment on pulp drying machines.

The sheets from the cutter fall into boxes as they are cut. From the boxes they are piled on a scale until a bundle of 450 lbs. is made.

The platform of the scale consists of a roller conveyor section 36" in width. A roller conveyor carries the bundle to the hydraulic press where it is pressed at about 100 tons per square inch. After the press is released the bale expands to about two-thirds its original thickness. It is desirable, of course, to compress the bale as much as possible to secure a minimum cargo displacement, particularly for export shipment.

Bales are stencilled with the customer's name, the date made, and serial number. The serial number allows tracing the complete history of the pulp if desired at a later date. The wrapping is specified to be of identically the same pulp as the sheets in the bale. The wrapper size used is 50" x 60" also made on the Kamyr cutter which can be adjusted to cut sheets of any size from 24" x 32" to 62" x 104". As all pulp made is repulped and made into paper at some other mill extreme care is taken to keep the sheet of pulp as clean as possible. Color, dirt, strength and moisture content are constantly checked, and the same care is given to maintaining the pulp at a high level of quality as is given to quality maintenance on the paper machines.

CHAPTER XVI

STOCK LOSSES

By M. J. FRANKLIN

It has been estimated that fiber losses are costing the pulp and paper industry in this country more than six million dollars a year. Like most progressive mills, the Camas plant has been giving more and more attention to this problem and efforts are continually being made by installing measuring instruments and filtering equipment, to reduce fiber losses to a minimum, with results that are very encouraging.

The first consideration in attempting to lower the fiber loss, in a paper mill, is to find out the actual quantity going down the main sewer. After the total loss is determined checks can be made on each machine or division of the plant in order to study ways and means of eliminating individual losses.

Determining Stock Losses

Three things have to be done in order to arrive at a reliable figure for losses of fiber at any point in the system. These are:

1. Accurate flow measurements.
2. Collection of properly representative samples.
3. Analysis of samples, and interpretation of results.

Measurement of Flow

The measurement of flow in checking stock losses is done with some type of weir. The best type to use wherever possible, is a double end, con-

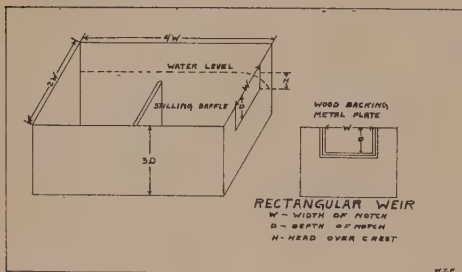


Fig. 103
Rectangular Weir

tracted, thin edged rectangular weir. Fig. 103 shows a weir of this type. It is not possible to build a perfect weir in every location due to limitations

of space or arrangement of piping. When this condition exists, necessary corrections are made to the readings.

The important features of a weir are:

1. The flow box must be large enough, and with sufficient baffles, to quiet the flow until there is substantially no velocity of approach before the weir notch.

2. The notch must be horizontal and sharp crested. It is usually a thin metal plate or a heavy bevel edge metal plate. The plane of the upstream face must be vertical.

3. The water should have a free fall after leaving the weir notch.

4. The head should not be over half the width of the notch and not more than one-third the depth of the water in front of the weir crest.

Liquid level gauges of the standard pressure type are used to give a recorded chart reading of the head. The total gallons are calculated from Francis' formula as follows:

$$Q = 3.33 \left(W - \frac{H}{5} \right) H^{3/2}$$

Q = Flow in cubic feet per second.

W = Width of weir notch in feet.

H = Head over the crest in feet.

Sampling

In order to get a representative average sample, it is necessary to devise some system of continuously sampling the flow, or sampling it at frequent periodic intervals. In use at Camas are two types of sampling mechanism which will be described briefly.

Fig. 104 shows an automatic trip sampler used on weirs that are built above the floor, and whereby samples can be withdrawn by gravity. A steady stream is discharged into the bucket which, when full, trips itself, thereby discharging a portion of its contents into the sample can.

Fig. 105 shows a motor-driven sampler as used on main sewers and deep gutters difficult of access. Small buckets mounted on an endless belt collect the samples.

The composite sample, secured by one of the above means, is mixed and a one quart portion filtered through previously weighed filter paper. The sample and filter paper are then dried and weighed and the difference between the original weight of the filter paper and the total weight of the dried sample plus the filter paper gives the weight in grams per quart. By means of a factor this is converted to pounds per 1000 gallons.

The following calculation gives the total loss as pounds per ton of production:

$$\frac{\text{Gallons per 24 hours} \times \text{Pounds per 1000 Gallons}}{\text{Total Tons Made}} = \text{Total pounds lost per ton of production}$$



Fig. 104
Automatic
Trip Sampler

The loss thus measured and calculated is the total suspended solids, or solids that do not go into solution. In mills that use a large amount of chemicals it is necessary to test for dissolved solids. This is done by evaporating the filtrate, weighing the dried residue, and calculating as before.

The total solids consist of two ingredients that are of interest to the Camas plant. First, the fiber content, and second, any filler or pigment used.

To determine the amount of filler lost the total sample is ashed in a muffle furnace at approximately 1400° F. and weighed. The calculation is made as follows:

$$\frac{\text{Weight of Ash} \times 100}{\text{Total weight}} = \% \text{ filler in sample.}$$

This figure may be also converted to pounds per 1000 gallons, if desired.



Fig. 105
Motor Driven
Sampler

Considerable work has been done on the type of fibrous material lost from the pulp and paper making machines and saveall equipment. Over an extended period samples were fractionated by washing through a 90 mesh wire, this being simple drainage with no vacuum applied. The fiber that was retained on the wire was considered usable fiber, and that which went through as stock which could not be held on the wires of the equipment in use or, in other words, non-usable fiber. It was found that the stock leaving the mill via the sewer was 41% usable fiber and this value, having been

thus established, is used as an average figure in the calculations of potential recovery.

Paper Machine Losses

Paper machine losses are considered under two different classifications, continuous and intermittent losses.

Continuous losses are for the most part made up of filtrate, suction pump discharges, and miscellaneous drainage from felt and wire showers, etc. The filtrate loss is by far the largest of this group and is measured separately on each machine. Measuring the filtrate is important in that it helps to determine the efficiency of the filter as well as showing the actual loss.

This group of losses is made up of white water overflows, color change losses and shutdown losses.

The white water overflows are checked separately on each machine, this also serving to show the amount of white water being handled by filters as a further check on filter efficiency.

The color changes and shutdowns are measured in a total loss weir in the sewer. The machines have proper sewer sampling equipment as have also the bleach plant and wet rooms.

Filters

Most of the white water recovery at Camas is effected through the use of Oliver Continuous Filters. These filters are of the rotary vacuum type, and are well adapted to this work in the respect that they are able to handle furnishes varying widely in freeness, fiber quality and filler content.

The white water is pumped from the white water pit or chest and enters the filter near the bottom, together with the sweetener stock which is added in amounts to increase consistency to about 20 to 30 pounds per 1000 gallons. The sweetener stock is preferably beater stock and is the real filtering medium since the wire cover on the filter, which is under a vacuum, will not retain the short fibered stock in the white water, which has already gone through a similar wire. The sweetener stock also provides a more porous sheet upon the revolving drum facing and decreases the tendency of the short fibered white water to pack in a dense sheet while the filtering compartment is submerged. The formation of the fiber mat by the suction is almost instantaneous. The short fiber retained on this mat and returned

to the system is valuable in improving the formation and finish of the paper.

The white water and sweetener stock fill the filter to the level indicated. An overflow pipe is provided to keep the level at this point for uniform operation. The stock overflowing goes back to the white water pump. The water leg creates the vacuum for the filter, while removing the filtrate.

Fig. 106 shows a diagrammatic sketch of the principal parts of an Oliver filter.

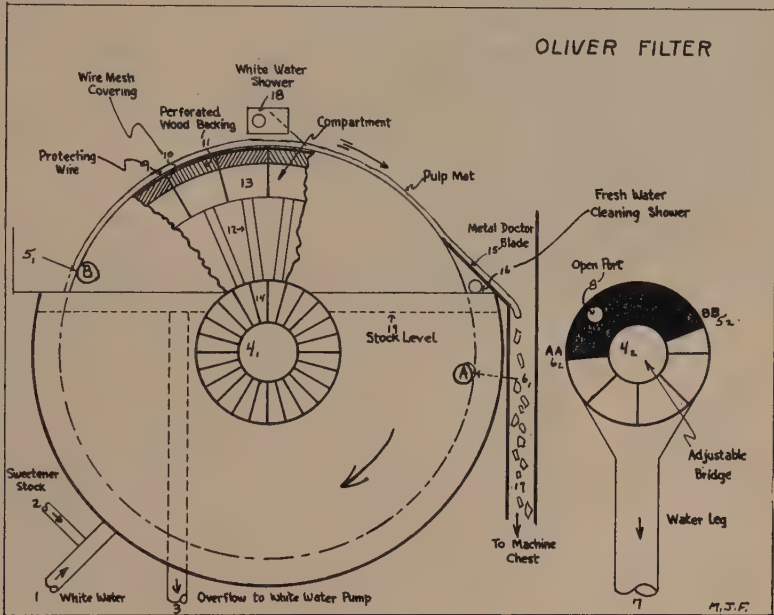


Fig. 106 Working Parts of the Oliver Filter

As shown, each individual compartment on the filter has first an inside layer of wood, which is grooved on top and perforated through to the compartment. Over the wood backing is attached the wire cloth covering, which is Fourdrinier wire from 60 to 80 mesh. A wire wrap is applied to hold the wire cover in place and protect it from direct contact with the metal doctor blade.

The metal doctor blade removes the mat from the drum and rides on the wrapping wires. There are other methods used elsewhere for removing the sheet from the drum, such as: couch rolls, air blown inside the drum through a port, and special types of doctor blades which remove the sheet by a shower of water or air blown from under the contact edge of the doctor blade.

The purpose of the shower under the doctor blade is to clean the drum between the time the sheet is removed and the point of immersion.

The recovered stock drops to the machine chest, where it rapidly disintegrates to a uniform suspension and mixes with the machine stock.

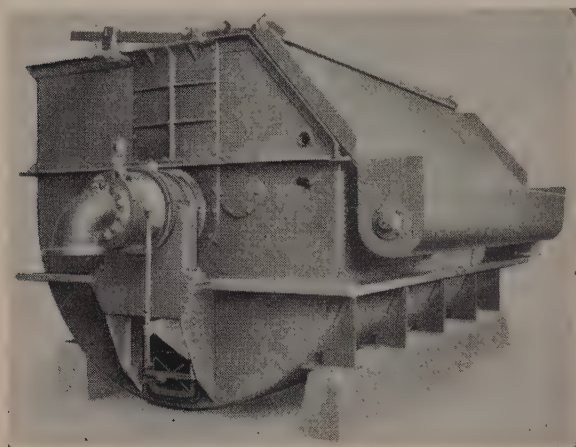


Fig. 107
Oliver United Saveall

A white water shower softens the sheet and helps in removing it easily from the drum.

The automatic valve is shown in two parts. The face plate on the drum includes the ports and revolves with the drum. Each individual port is connected with a compartment of the filter.

The adjustable stationary bridge sets against the face plate when assembled. This bridge can be moved in relation to the annular ports so that the arc in which the filtrate connections function may be increased or decreased to any desired point. The flexibility through which the outlet can be made to function is one of the outstanding features of this filter.

The shaded part of the bridge on the sketch is adjusted to allow vacuum to be applied shortly after the drum is submerged. Point A on the drum is relative to point AA on the adjustable bridge (Fig. 106). The vacuum is held until reaching point B on the drum corresponding to point BB on the bridge.

The open port in the shaded area of the bridge may be used for several purposes. It may be left open to the air which would allow each section to completely lose its vacuum as it passes this port. This may help in sheet removal, and air may be injected at this port to blow the sheet off the drum. A pipe may be connected to this opening and the drainage accumulating from the time the vacuum was stopped at BB until reaching the port, may be sent to the filtrate weir.

As the drum revolves the vacuum gradually builds up as the thickness of the sheet increases. During the time the vacuum is applied, water is being drawn into the compartments and is discharged through ports at the end of the hollow shaft. The effluent loss should not exceed 1 pound per 1000 gallons.

The Oliver-Young filter was developed several years ago as an improvement on the usual type of Oliver filter, having the advantage of increased drainage capacity per square foot of drum area and being able to revolve at higher drum speeds.

American Disc Filter

The principal difference between the Oliver and American filters is in the construction of the forming wire. The Oliver is a drum type while the American is a disc filter similar to the type shown in Fig. 108. The advantage of the American filter is that it occupies less floor space per square foot of wire surface.



Fig. 108
Disc Type Filter

The amount of water needed to remove the sheet from the wire on an American is much larger than used on an Oliver filter and its maintenance costs are somewhat higher, according to Camas Plant experience.

Stock Loss Utilization

After determining the fiber concentration and volume of white water to be handled, the first step is to study the most economic ways to re-use this fiber. The method for re-using white water is primarily to replace, wherever possible, fresh water with white water. This includes the beaters, fan pump, chests, equalizers, jordans and the headbox. In this way we reduce the load on the filters, and reclaim alum, anilines and other soluble materials, sending to the filter only the excess white water that cannot be directly used.

The filtrate from the filters can be used to replace fresh water in

the headbox, screen showers and breast and wire roll showers. If an excess of filtrate remains, it can be piped to the vacuum pumps and used as sealing water. This latter application, recently put into effect, eliminates the fresh water formerly used at this point.

All of the white water and sewer losses cannot be re-used as the machine system must be kept partly open to keep it clean and free from slime growth. Frequently the entire white water system is washed out with soda ash. Bacteriological control is often necessary to secure maximum utilization of all waters of the paper machine.

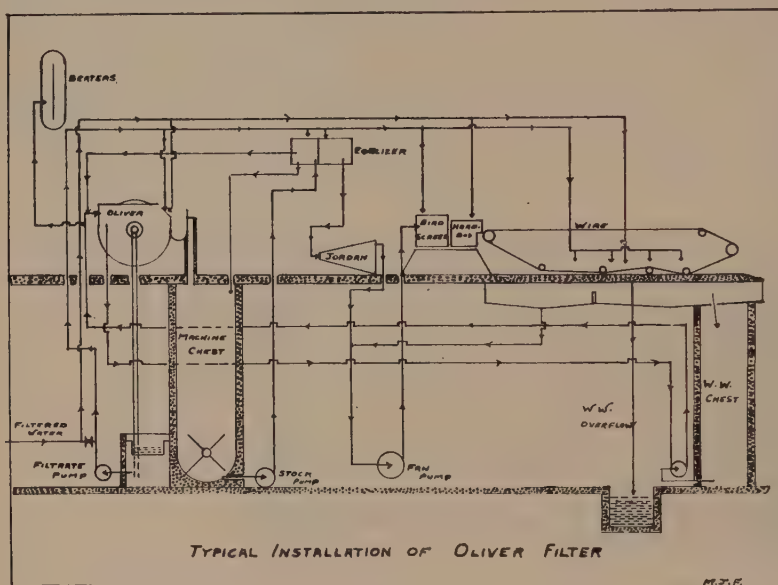


Fig. 109

Fig. 109 shows a typical machine white water system using an Oliver filter. The different conditions existing on various machines makes it necessary to have each machine hooked up a little differently.

In order to keep a history of progress in reducing stock losses, daily records are prepared and issued to the operating departments with suggestions for improvement, and a weekly summary of stock losses is compiled for comparative purposes.

In all studies pertaining to reclaiming fiber from sewers, it is well to adopt as a primary consideration the cost of recovery, as careful investigation sometimes discloses that the cost of reclaiming fiber at a point of effluent loss may exceed the actual potential value of the recoverable material.

CHAPTER XVII

FINISHING ROOM OPERATIONS

By P. V. MILLARD

Upon completion of a reel of paper on the paper machine, equally important steps must be taken toward preparing it for shipment in the finishing room.

The operations of this department may be discussed in general under the following headings:

1. Types of finishing and equipment used.
2. Department organization.

There are four general ways in which paper is finished, jumbo rolls, counter rolls, bag rolls and sheets.

Jumbo Rolls

These are large diameter rolls made on the paper machine, slit and rewound on three-inch paper cores, wrapped, labelled and stencilled for shipment according to specifications for grade, basis weight, etc., shown on the order department program. These rolls will run up to 36 inches in diameter. Plugs are inserted at each end of the core, body wrap is put on at the winder and protecting bands are applied on the ends. Inner heads are inserted, the bands are crimped over the ends and finally the outside heads are pasted on.

The machine program specifies the number and kind of body wraps and bands, also the number of top and bottom heads and the kind of cores and plugs. The finishing of jumbo rolls is the simplest type of finishing and the only equipment required is the winding drum installation at the paper machine winder.

Counter Rolls

These are smaller rolls of the size used on counters in retail stores. They are rewound from machine jumbo rolls on rewinders of which there are several different types. Among these are the Kidder, Langston, Beloit and Cameron. They are essentially the same in principle of operation, the chief difference being in the mechanism for slitting. The Kidder has saw-tooth slitters riding on top of the rewinder roll, the Langston has the slitters on the front of the machine. The Beloit rewinder slits the paper

through a top and bottom slitter similar to the slitting mechanism on paper machine winders. On the Cameron rewinder the paper is slit by means of blades running against a chilled steel roll making a very smooth edge free

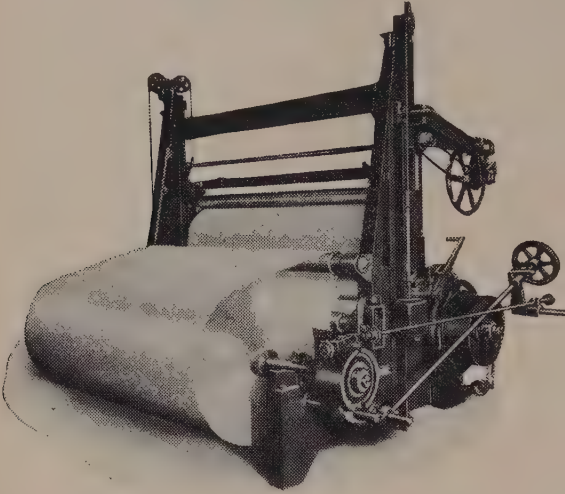


Fig. 110

Cameron Rewinder
(Rear View)

from dust. This method, known as "Score Cut" slitting, was developed by the Cameron Machine Company and has been found to be most satisfactory over long periods of use.

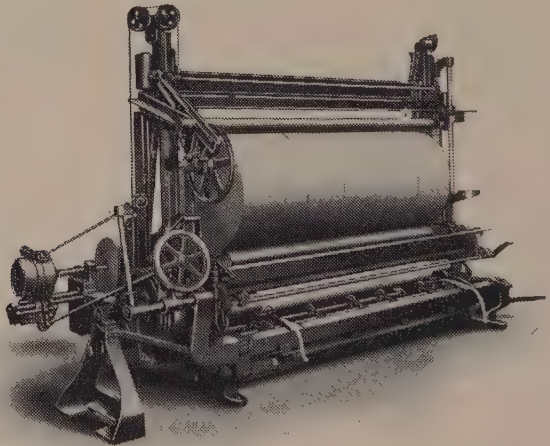


Fig. 111

Cameron Rewinder
(Front View)

Counter rolls may either be made directly on the paper machine winders or the paper may be wound into a jumbo roll on the paper machine and rewound into counter rolls in the finishing room. In either event the paper roll is placed at the back of the winder, threaded through its various

rolls and wound around a shaft located between the winder drums. Inasmuch as most counter rolls are wound without cores, a collapsible shaft is generally used. When the required diameter is reached, the shaft and roll are removed from the machine and another shaft put on. As the new roll is being run up, the first shaft is removed from the roll or rolls and a wooden plug is placed in either end of the counter roll. Thus by using two shafts the rewinder can be kept running almost continuously.

From the rewinder, the counter rolls go to the wrapping department for finishing. The usual way is to put a heavy wrap around the roll, allowing this to project about three inches over either end. An inside head is inserted, the wrapper crimped over the ends, and outside heads pasted on. Labels and shipping marks are then put on and the counter rolls are ready for shipment. Wrapping is done carefully in order to properly protect the product and give it an attractive appearance.

Bag Rolls

Most of the bag rolls produced are for use in the bag factory so there is very little finishing required other than bands on the bottom to prevent damage while being transported to the bag factory.

Sheets

Cutters are used to convert paper from rolls to sheets. There are five of these in the two finishing rooms, each equipped with layboys. The layboy is the mechanism, usually an integral part of the cutting equipment, for piling the sheets. There are three 128" cutters, one 96" and one 75" cutter for wrappers. Tissue cutters will accomodate 30 to 36 rolls at one time. A 128" roll will weigh about 1,800 pounds, which means that a cutter can process 30 tons of paper at one time. As a cutter knife will only handle up to 600 pounds total basis weight (for example, 24 rolls of 25 pound paper) the cutters for heavier grades have backstands equipped for only 12 rolls.

Fig. 112 shows one of the Camas sheet cutters. After the rolls are mounted on the shafts, the paper is threaded under a guide roll, through the slitters and into a steel or rubber squeeze roll the function of which is to turn the unwinding rolls. The squeeze rolls feed the paper into the knife, the speed of which is adjustable for a varying length of cut. The knife is secured in a cylinder, driven by a belt on cone pulleys. The bed knife is fastened to a stationary plate, and the faster the rotation of the cylinder the shorter the sheet cut off. The slitters also are adjustable for varying width of sheets. The machine room endeavors to supply all the cutter rolls on any given cutter set of the same diameter to facilitate running to the proper sheet count and minimizing the waste.

Three of the cutters are duplex cutters each equipped with two knives to allow cutting sheets of two different sizes simultaneously. For example, if 30" x 40" sheets are to be cut from 112" rolls, the slitters would be set up to slit two sheets 40" wide and one 30" wide. The two 40" widths would

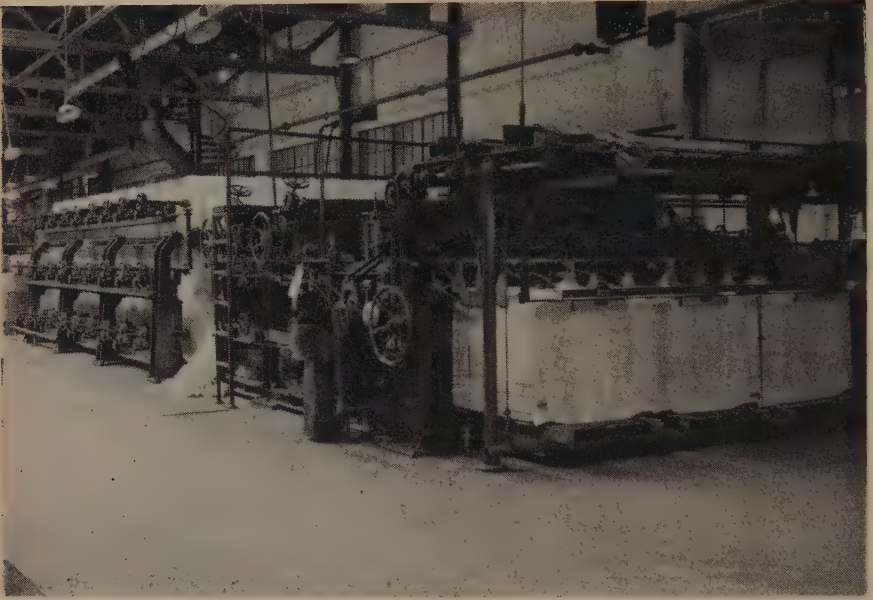


Fig. 112 Cutter

be passed through the first knife and cut off in 30" lengths. The 30" width would bypass the first knife and be cut in 40" lengths by the second knife. This arrangement allows the finishing room to take advantage of wider rolls, thereby increasing its cutter capacity and reducing cutting costs.

After passing through the knives, the sheets, now cut to size, drop to moving tapes which transport them to the layboys. The layboys are equipped with lowering devices so that the top of the load is always at a constant level. By this means the cutter can be operated without interruption until a pile of sheets about 40 inches high has accumulated. After a full skid has been cut it is removed, an empty skid put in its place, and raised to the starting position.

Sheets are packed in three ways:

1. Flat pack.
2. Soft fold.
3. Quire fold.

In the flat pack, the sheets are piled in bundles of suitable size with no folding.

Sheets are packed soft fold by interfolding alternate reams. The reason that the soft fold pack is used is that some customers do not want the paper creased, yet the sheets are of such large dimensions that the bundle would not hold together unless packed with heavy chipboard or crated at extra expense. The soft fold gives no crease yet makes a compact bundle.

The quire fold pack is the most expensive way of packing sheets. In the heavier weights, each 24 sheets is tagged in cutting then folded by hand. The fold is usually made the short way to give a bundle as nearly square as possible in order to carry well in transit. Tissue grades are quire folded mechanically by means of a Brannon folder installed on one of the tissue cutters between the knives and the layboy.

The Brannon folder operates automatically. The 24 sheets (constituting the quire) are cut by the knife, drop to the conveying tapes, and strike a backstop underneath which are two revolving rubber rolls. As the paper strikes the backstop a dull blade above the center of the sheets is actuated to force them down between the rubber rolls thereby creasing them in the center. The folded sheets are then conveyed to the layboy by means of a separate set of tapes.

Some customers specify that each ream be banded. This is done by folding a sheet of kraft around the ream securing it with gummed tape. The ends are not enclosed. In some cases, particularly with bleached tissue and napkins, the reams are "ream sealed," or completely enclosed in a kraft wrapper of about 40 pound basis and secured with gummed tape.

Bundles may either be tied with rope or sealed with heavy gummed kraft of 70 pound basis weight in widths from 4 to 10 inches.

Some orders call for skidpack shipments. A skidpack is a wooden platform built on runners. After bottom wraps have been placed on the platform, the sheets are neatly piled to a height of about five feet. Top and side wrappers are then placed in position, a wood top put on and strap iron secured around the complete unit. For added protection wooden corners are nailed from the top to the bottom platform. Labelling and adding the proper shipping marks completes the pack. In most cases the skids are non-returnable.

On orders for large sheet sizes, instead of soft folding we sometimes pack the sheets flat with chipboard stiffeners or wood frames as specified by the customer.

The finishing room is equipped with four ream trimmers of the type illustrated in Fig. 113. These are machines for cutting a stack of sheets about six inches high with a single stroke of a sharp heavy knife. On a cutter

there is about $\frac{1}{8}$ " to $\frac{3}{16}$ " difference in length between top and bottom sheets of the cut due to the shearing motion of the knife. Where orders require sheets of exact size it is necessary to trim them on all four sides on a ream trimmer. In addition, it is often impractical to cut sheets on the cutter to the exact size ordered by the customer. For example, fruit tissue in sheets 9x9, 10x10 or 11x11 is best handled by cutting multiples of these sizes in the cutter and subsequently trimming to exact size.

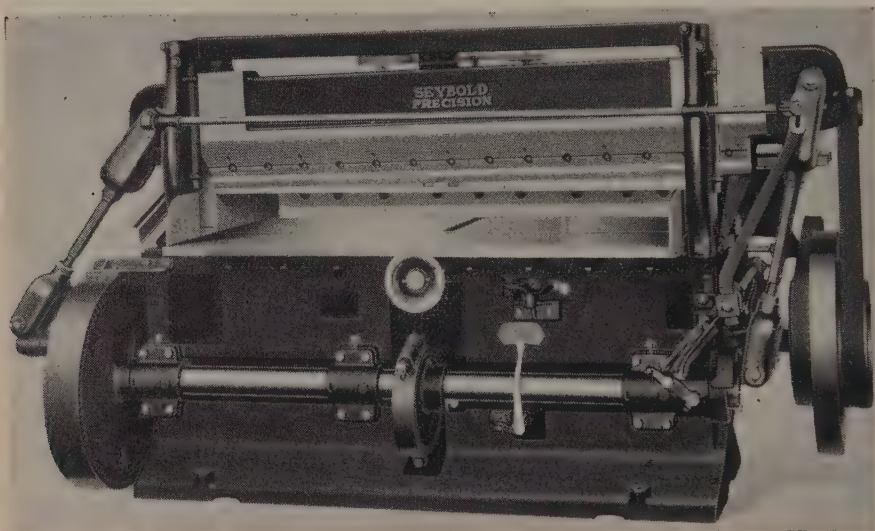


Fig. 113 Seybold Ream Trimmer

Some customers require the grain a certain way or the crepe running a certain way. This complicates the problem of calculating the most advantageous machine trim particularly if the order is to be duplexed on the cutter.

The finishing room also includes the core making department with two core machines. One makes the 3-inch cores used for jumbo rolls. These are 16 ply cores made from special 185 pound core stock. The other machine makes cores from 1" to $2\frac{11}{16}$ " inside diameter for special uses. These machines are similar in operation. Using silicate as an adhesive, the cores are wound spirally into a continuous tube, cut into long lengths, allowed to season for shrinkage then cut to lengths required. Small cores for toilet rolls are made on a separate machine as described in Chapter XIX.

The finishing department also has accessory equipment such as a rip saw, cutoff saw and band saw for making skeleton and solid frames and skids for skid packing. This equipment is also used for cutting the outside paper heads for counter rolls.

Department Organization

With the large number of different grades, sizes and colors to be handled, most careful attention to planning the routing of this work is required to finish all paper according to orders and meet shipping dates.

Orders from San Francisco are programmed by the mill order department. When copies of programs are received at the finishing room, they are studied carefully and if there is any way found to decrease the waste by change of machine trim, or any way that the orders can be manufactured more expeditiously, the order department is called and the necessary changes made.

Programs showing grade, basis weight, count, size, weight of rolls and number of sets to be made are issued to the machine room and the paper made accordingly. A tag showing this program number is placed in every roll and the rolls delivered to the finishing room. If the paper is to be cut into sheets, additional programs are issued to the cutterman showing exact details of sizes to be cut, slitter settings, number of reams of each size, etc. When the paper is cut, a skid tag is placed in each skid showing program number, grade and size; also final size to be trimmed to if sent to the ream trimmer in which case duplicate programs are sent to the trimmerman. By careful attention to these details, the orders are routed through in an organized manner with no confusion and minimum chance for error.

One copy of the order department program is also given to the wrapperman so that he can cut, stencil and label the wrappers in advance of the time the sheets are to be bundled.

When the paper has been cut and trimmed it is ready for inspection and baling. The inspector has a daily schedule made up so that cutters, trimmers and balers can give prior attention to orders requiring early shipment. Also, slips are made out each day showing programs worked on so that the status of each order can be determined at any time.

The aim of the Finishing Department is to ship paper of the highest quality in exact accordance with customers' specifications, at the right time, and at the lowest cost. All shipments are carefully inspected and any defective paper discovered is culled out. Inspectors must watch a great many features for defects and errors. In the first place the count must be accurate. The usual count is 480 or 500 sheets per ream, but there are requests from the trade for sheet counts from 100 to 1000. Complaints have been received from customers in the West Indies where shipments of tissue paper were short one sheet. In this case the customer employed cheap labor and could afford to count the sheets. To be on the safe side, it is usual practice to run a few sheets over the required count. Size of sheets, finish

on the paper, color variation, dirt specks, wrinkles, calender cuts, slime holes, streaks and other such defects are carefully watched for.

Each operator in the Finishing Room is also an inspector and when he discovers errors and defects brings them to the attention of the proper parties. Technical control is well organized in the Camas plant and the Finishing Department endeavors to assist the Technical Department in every possible way to maintain standards of quality.

In a way, the Finishing Department is a link between Manufacturing and Sales Departments. No matter how much skill is built into the paper or what modern efficient selling methods are employed, both can be greatly handicapped by sloppy looking packages, labels askew, and wrong markings. Realizing this, it is the aim of the Finishing Department to turn out a packaging job that the Sales Department can offer to the trade with justifiable pride.

CHAPTER XVIII
THE BAG FACTORY
By J. L. SHIVELY

The manufacture of paper bags by machine has developed entirely within the present generation. In 1850 a paper bag was a distinct rarity, and the records of these days tell us that paper bags were regarded as some new fangled nonsense, a passing fad that would never replace hand wrapping of commodities in paper. Today we cannot truthfully say that bags have actually replaced wrapping paper in its ordinary uses, but it is noteworthy the terrific strides the paper bag industry has made in the past fifty years. Bags are now one of the fastest moving items of commerce and some 50 billion of them are used in this country alone each year. The Camas bag factory makes close to two billion bags each year, enough to supply a bag to every person on earth. The paper bag has now come to occupy such an essential part of our daily affairs that few people realize the rapid rise of this comparatively new industry.

In the early years of the industry, bags were made entirely by hand. The first automatic bag machine was built in 1876, and since that time such advances have been made in mechanical design and construction that we now have machines at Camas that print, cut, fold and paste six bags every second, a quarter of a million per day.

It is interesting to note, however, that the old Doolin bag machines, the same ones used by Mr. Louis Bloch in his bag business in San Francisco before the earthquake more than thirty years ago, are still in operation.

Types of Bags

The four most common types of paper bags are the flat, square, self-opener and satchel bottom bags. These are illustrated in Figs. 114, 115 and 116.

The flat bag was the first type of bag, developed about 1850, and later was the first type to be made by automatic machine. It consists of a flat tube with about one inch folded and pasted, forming the bottom, and is used principally in the packaging of flat articles. This style of bag is manufactured in 18 sizes, ranging from $\frac{1}{4}$ pound up to 35 pounds capacity, but mostly in the smaller sizes. It is made from both sulphite and kraft paper in basis weights varying from 30 to 40 pounds per ream, according to the bag size.

Sizes of bags are expressed in values originally designed to represent the nominal capacity of the bag in pounds. The present standards are used

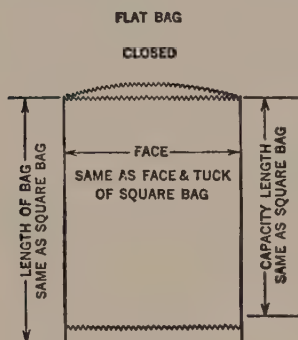
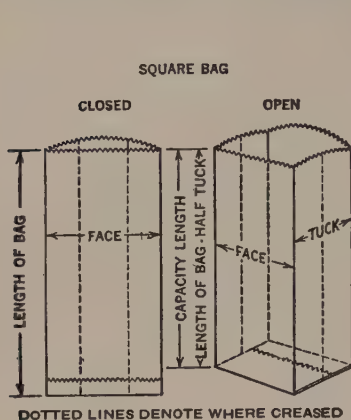


Fig. 114

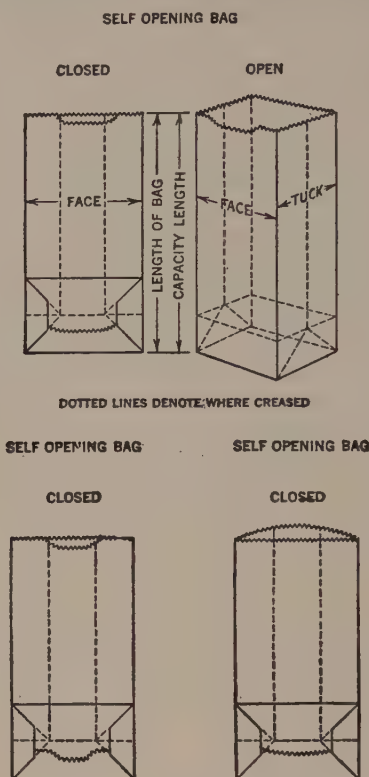


Fig. 115

generally in the bag industry and were established by the U. S. Bureau of Standards in 1925 based on the cubic contents of the bag. A manufacturer whose bags comply with these regulations is entitled to print on his bags the designation "SS", meaning "Standard Size."

In 1872 the square bag came into existence as an improvement over the flat bag. It is similar in construction to the flat bag except that it has bellows in each side. It is used more for bulky merchandise. The range of sizes is the same as for flat bags.

The automatic or self-opener bag was first manufactured about 1883 and is the most popular style of paper bag. It has a tuck or bellows and a flat bottom. It can be opened with a flick of the hand, and for this reason is called a self opener. This type of bag is made for every possible use and in a large variety of sizes.

There are two types of self-opener bags. The one where the bottom is folded back on the seam side of the bag and the other on the face side. The former is made on Potdevin machines and the latter on Parrish machines. The bag with the bottom folded on the face is the more sift-proof, while the one folded on the seam side leaves the face of the bag free for printing.

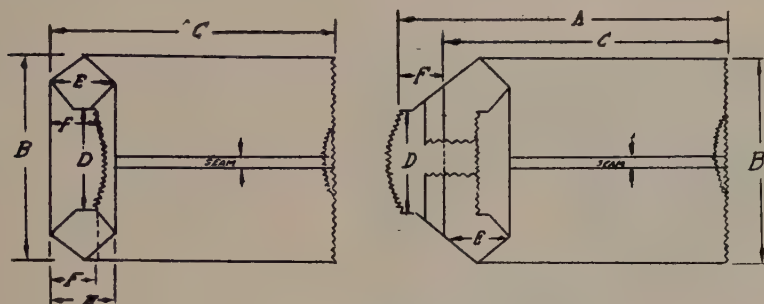


Fig. 116 Satchel Bottom Bag

The satchel bottom bag, like the flat, has no tucks, but its bottom folds can be opened out to form a flat surface so that the bag can stand erect. It is usually made in the larger sizes for bulky materials such as nails and coal, and which cannot be made on self-opener bag machines.

Manufacture of Bags

Bag paper is received in rolls 26 to 30 inches in diameter on three inch paper cores and in the proper width to make the desired size bag.

These rolls are delivered to the bag machines where the operator inserts a shaft with taper cones or chucks on either end. The roll is then mounted on the roll brackets of the bag machine and the friction and guide arm are lowered in place. This keeps the roll of paper in the same lateral position at all times. The paper is then threaded around a slack roll and over the impression roll where the size is printed on the bag, then to the paste roll where the seam paste is applied. From this point the paper is brought over the former (which is a piece of steel about $\frac{1}{8}$ inch thick and of proper width to correspond to the size of the bag) and into the draw rolls. These rolls feed the paper to another set of rolls called the pinch bar rolls. This pair of rolls travel at a slower speed than the draw rolls, which results in a certain amount of slack in the paper at this point. This is done to make a better cut-off operation for the striker arm. Most bags are cut with a serrated edge as this is a much faster operation than a smooth die cut. After the tube is cut off it enters the gripper roll (which is the lower roll). The top roll carries the tucker, for creasing the bag into the gripper and paste pad for pasting the bottom. The gripper carries it under the ironer

roll and delivers the bag to a carrier belt discharging into a receiving box. When fifty bags have been delivered into this box an electric kicker pushes one bag out of line so that the girl tending the machine will know when to take them out. They are then inspected and two bunches of fifty each are tied together making a package of one hundred. These are stacked five high on a skid.

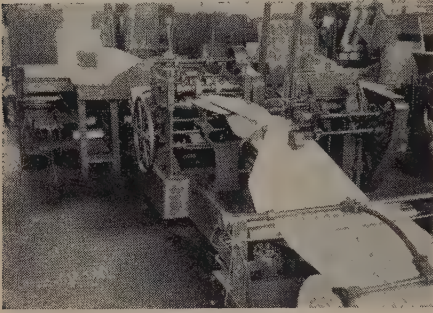


Fig. 117
Potdevin Self Opener
Bag Machine

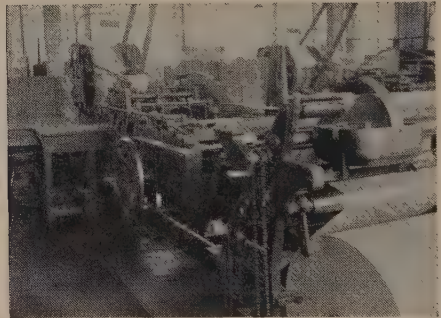


Fig. 118
Parrish Bag Machine

Shopping Bags

Shopping bags are made on machines that crease the top for folding in and punch the hole for inserting the handles. The tops are folded in by girls and cardboard is placed under the fold. The handle cord is then inserted in the holes and stapled in place.

Bag Finishing

When a skid is full it is delivered to the finishing room where each five hundred is put into a pneumatic press. A 50-pound kraft wrapper is placed around the bundle and tied with two strings. A label is placed on each package designating the size and grade. After the bags are pressed they are again wrapped into shipping bales, which contain from one to twelve

thousand, depending on the size of the bag. Two 150-pound wrappers are used for the bales which are sealed with gum tape. These bales are labeled designating sizes and grades and the bags are then ready for shipment.

Thirty-four types of bags are made at Camas. It may be of interest to list some of these.

SPECIALTY FLAT BAGS

Millinery bags are made from 25 pound paper in five standard sizes: 10x13, 12x15, 15x19, 17x21, 21x24.

Notion bags. 25 pound paper in 6 sizes: 3x5½, 4x6¼, 5x7½, 6¼x9¼, 7½x10½, 8½x11.

Garment bags. 25 pound paper. 23¾" width face, 30, 36, 40, 50, 54, 60 inch lengths.

Pants bags. 25 pound paper. 18" wide and 30 and 32" lengths.

Laundry bags. 25 pound paper. 18" wide, 27" long. These bags have an eyelet and string attached at top for tying.

SPECIALTY SQUARE BAGS

Raisin bags. 55 pound paper. Made in 2 and 4 pound sizes.

Raisin liners. 25 pound paper. Liners for 25 pound boxes.

Bread bags. 25 pound paper. Made in 25 various sizes.

Liquor bags. Made in ½ pint, pint, quart, 2 quart and gallon sizes.

Banana bags. 30 pound paper. Made in 14" width, 40 to 52" lengths.

Egg crate liners. Made from waxed kraft and laminated paper.

Carbon black overslip bags. Made from light and dark gray kraft, one and two ply.

SPECIALTY SATCHEL BOTTOM BAGS

Barrel bags. Made in 1/16, 1/8, 1/6, 1/4 barrel sizes.

Poultry bags. Made in various sizes.

Powder bags. One and two ply waxed and plain paper.

Shopping bags. Made in three sizes with handles attached.

Carbon black. One, two and three ply.

Nail bags. Made from 40 to 60 pound kraft in 3, 5, 8, 10, 16, 20 and 25 pound sizes.

SELF-OPENER SPECIALTY BAGS

Donut Duplex bags with glassine liner made in three sizes.

Confectionery bags made from bleached sulphite in ¼, ½, 1, 2 and 3 pound sizes.

Raisin carton liners made from oiled sulphite.

Carbon black. One, two and three ply.

STANDARD CAPACITY SELF-OPENER BAGS

SIZE	CAPACITY	SIZE	CAPACITY	SIZE	CAPACITY
1/4 lb.	16.87 cu. in.	5 lb.	191.80 cu. in.	16 lb.	593.60 cu. in.
1/2 lb.	30.84	6 lb.	240.40	20 lb.	700.48
1 lb.	51.66	8 lb.	304.04	25 lb.	779.97
2 lb.	83.78	10 lb.	350.17	30 lb.	846.84
3 lb.	119.98	12 lb.	433.28	35 lb.	1002.22
4 lb.	151.98	14 lb.	545.98		

STANDARD CAPACITY SQUARE AND FLAT BAGS

SIZE	CAPACITY	SIZE	CAPACITY	SIZE	CAPACITY
1/4 lb.	16.41 cu. in.	5 lb.	191.02 cu. in.	14 lb.	545.42 cu. in.
1/2 lb.	30.03	6 lb.	240.04	16 lb.	593.47
1 lb.	51.17	7 lb.	277.45	20 lb.	700.69
2 lb.	83.04	8 lb.	304.76	25 lb.	779.23
3 lb.	119.08	10 lb.	350.25	30 lb.	846.26
4 lb.	151.02	12 lb.	433.81	35 lb.	1002.67

Bag Machine Types

The Camas Bag Factory has 75 bag machines representing a variety of machine types as required to produce the different styles of bags manufactured. These are as follows:

Parrish machine.

Duvall Square machines.

Doolin Flat and Square machines.

Potdevin, notion bag machines with printing attachment.

Potdevin Flat and Square machines.

Potdevin Automatic Bag machines.

Potdevin Sack machine—carbon black bags.

Potdevin Large Square bag machines.

Millinery bag machine.

Satchel Bottom Nail, Shopping and Poultry machine.

Banana and Garment machine.

Duplex Tuber.

Raisin Bottomer.

Bag Printing

Some of the machines are equipped with printing presses so that bags can be printed and formed in the same operation. Heinrich aniline presses mounted on portable bases were recently installed, so that they can be

hooked up and synchronized with a number of the bag machines. This arrangement gives greater flexibility of operation.

Paste Making

The Bag Factory has its own paste making department located on the mezzanine floor. Here 30 barrels of paste are made up every day in tile-lined tanks, four feet in diameter and four feet deep, equipped with steam lines and agitators. A variety of materials is used, depending on the particular requirement. A thin paste is used for seams and a "short" heavy-bodied paste used for the bottoms to prevent stringing paste on the outside of the bags. Various starches and dextrins are used also casein and solvent pastes for waxed bags. In all cases the formulas and cooking schedules are carefully controlled to insure uniform operation and freedom from defective pasting, which may not show up until the bags are shipped out to the trade. Thirteen hundred miles of bag seams are pasted each day.

Inspection

Each bag operator is automatically an inspector, responsible for the quality of bags produced on that particular machine. There is also a skilled technician for inspection and testing of bag rolls and finished bags. The entire operation is under scientific control in an effort to produce a perfect commodity. Research work is being continually carried on in the plant and in the field to develop new bag uses and improve the present products.

CHAPTER XIX

THE CONVERTING PLANT

By H. W. DUVALL

The Converting Plant was added to the mill organization about ten years ago to meet increasing demands for high quality toilet tissue and paper towels. It consists of a concrete building 200 feet wide by 375 feet long, containing equipment specially designed for these products. Paper in jumbo roll form is delivered by electric trucks directly from the paper machines and a sufficient supply is kept in storage to enable the converting plant to schedule its converting machines to the best advantage. Part of the towel paper requirements is manufactured at West Linn and shipped to Camas for conversion.

The capacity of the converting plant is 4500 cases daily, equivalent to 90 tons of toilet tissue and 50 tons of towels. This is sufficient to keep ten million people in bathroom tissue and to supply the towel demands of over a million people.

The plant is located so that shipments can be made direct by rail or truck or by river steamer via the tramway system.

Paper Towels

In making paper towels, the rolls are first slit to the width of the towel and mounted on adjustable backstands on the machines. The paper is fed over cylinders where it is held in place while being cut to length, passing through a series of spiral folders to interleave alternate sheets. A special counting device marks the towels periodically so that the girls can put up packages with an accurate count. Printed bands are placed around the towels with a pneumatic banding device operated by a foot pedal so as to leave the operator's hands free. The banded packages are placed in shipping cases standing on a small roller loading platform beside each machine and when filled these are rolled onto the main gravity conveyor leading to the sealing machines.

There are eight of these towel machines, five being for plain towels and three for embossing. These machines make towels in $10\frac{1}{4}$ inch lengths and widths varying from 10 to $13\frac{1}{2}$ inches.

The embossed towel machines are similar in construction and operation except that a set of two embossing rolls is set ahead of each folding cylinder.

These rolls consist of one steel roll carrying the embossing design riding on a compressed paper roll carrying the same design in relief. The rolls are geared together and timed so that the patterns on the two rolls always nest exactly. Their purpose is to provide a softer towel with a pleasing

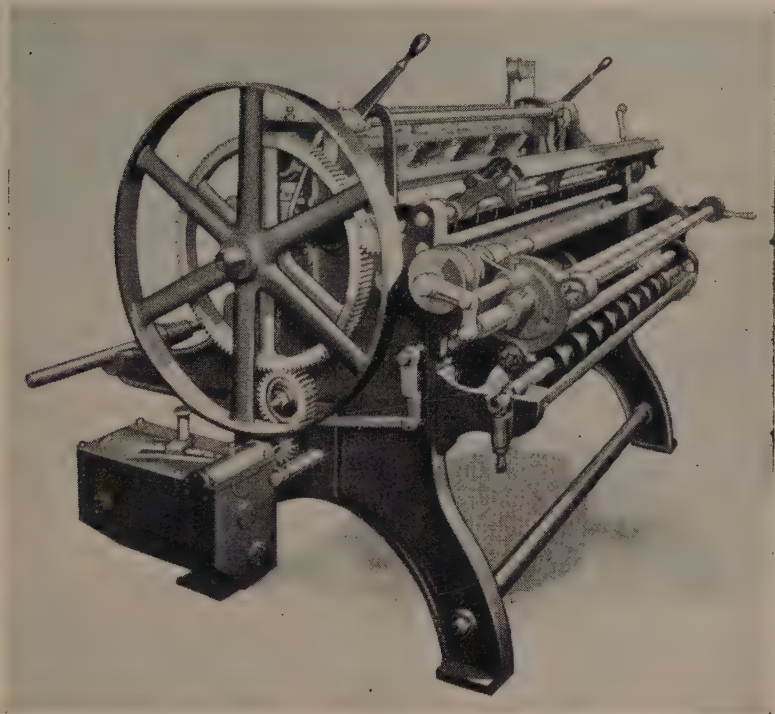


Fig. 119 Toilet Winder
—Courtesy Hudson-Sharp Mch. Co.

cloth-like texture. Different furnish papers emboss differently, a sulphite sheet, for example, being more pliable than a groundwood paper, will emboss more readily.

The standard pack for towels is 150 to a package and 25 packages to a carton or 3,750 towels per case. The sizes of these cases must be carefully calculated according to the caliper of paper being used. For example, paper calipering .00185 to .00190 inches requires a carton 18 inches high. For the most part, cases are made from 200 pound test board carrying up to 65 pounds gross, and in some instances a 275 pound board is used for cartons to carry up to 90 pounds gross weight.

There is also manufactured a household roll towel made from 100% bleached sulphite in 25 pound basis. This towel is made on a roll toilet

winder converted for the purpose. These towels are perforated in sheet^s 7½ inches long by 11 inches wide and are packed 24 or 50 rolls to a case.

Interfolded Toilet Tissue

This type of toilet tissue is used chiefly in office and public buildings. The interfolding mechanism is in general the same as in the towel machines. Four paper webs are fed in at one time and the sheets are slit, cut and interfolded in one continuous operation. The package is pressed and banded with a patented wrapper designed to facilitate refilling the cabinets. The cabinets will vend double sheets. These single fold machines have a capacity of 60 cases per day.

The standard pack on this tissue is 800 sheets per package and 125 packages per case, making a standard pack of 100,000 sheets.



Fig. 120
Toilet Interfold Machine

A more recent development in cabinet dispensing of toilet tissue makes use of what is known as a double fold interfold tissue. This has a narrower fold as it is folded twice instead of once as in the single fold grade.

This tissue comes out folded 45 inches wide, the operator then puts it in a press and glues the band around the package. This package is termed a cant. The cants are taken to a band knife, which is similar to a band saw but has no teeth. They are then cut into widths of 4, 4½ or 5 inches and packed 100,000 sheets to the case. The object of the double fold pack is to enable a narrower cabinet to be used which does not protrude so much from the wall.

Roll Toilet Winders

There are two distinct types of winders for roll toilet tissue known as hard-wind and soft-wind machines producing, as their names imply, tightly wound rolls in one case and loosely wound rolls in the other, according to trade demands. In the soft-wind machines, the winding shaft is suspended from either end and in the hard-wind machine it rides on two winding drums.

These machines produce a wide variety of brands, including roll tissue in various colors. Sheet counts of the finished rolls vary from 650 count



Fig. 121
Towel Interfolding Machine

to 2,000 count per roll. The rolls are packed 50 or 100 rolls per case, the standard pack being 100,000 sheets per case.

Roll Wrapper

Equipment has recently been installed to wrap the toilet rolls mechanically, replacing the old method of hand wrapping.

After the rolls leave the winder they are conveyed down to a roll breaker which separates rolls and transfers them over to the conveyor entering the wrapping machine.

Printed labels in a parent roll are mounted on the back end of machine. The printed labels are $13\frac{1}{8}$ inches center to center. The wrapper is threaded into the machine over a forming chute and side belts where a photoelectric cell picks up the printed register mark on each label energizing a solenoid air valve, which operates a cylinder feeding the rolls into the machine timed with the label feed.

After the roll enters it is glued and conveyed through forming chutes which place the label around it. The wrapper is still in a continuous web when it enters a double set of twisting belts where it is twisted or rolled so that a twisted knot forms between rolls. During the process of twisting there is an electric eye that operates the knives which cut the knot in the center to release the wrapped rolls from one another. After the rolls leave the twisting belts they are conveyed over a sensitive switch which energizes an air valve operating a cylinder which tucks in the ends. After the roll is completely wrapped and glued it is brought through a form which stands it on end and on to a conveyor ready for packing.

Notched Oval Machine

A special machine is used for making the notched oval type of toilet

tissue pack. This tissue is designed for an older type of fixture although there is still a considerable demand for it.

Sealing Machines

From the roll wrapper and other machines, cases are conveyed to the two automatic sealing machines. These are top and bottom sealers, in other words, the top and bottom flaps of the case are opened, glued, refolded, compressed and dried going through this complete unit.

Cores

Cores for toilet rolls are made on a high speed Langston core machine which forms and cuts the cores in one continuous operation at the rate of 15,000 $1\frac{1}{2} \times 4\frac{1}{2}$ inch cores per hour. Cores are distributed by a conveying system to bins located at each machine.

Conveying Systems

The plant is equipped with a Lawson overhead conveyor system serving both floors and enabling the operators to send packed cases directly to the cars for immediate shipment, or divert them to storage on either floor. This system also provides for loading cars from storage at the same time that cases are being handled from the sealing machines.

Dust Collector

In order to improve working conditions, the air in the converting plant is circulated and all dust and fine fiber particles that might prove injurious to health in continued breathing, are filtered out in a conical precipitator. In the winter time the air is heated.

General Design

The converting plant has been laid out as a straight line operation from jumbo rolls to finished cases. The various converting units are coordinated with the flow of materials—paper, cases, labels, and cores, so that there is no waste motion and a heavy tonnage of a large variety of products can be quickly and economically handled.

CHAPTER XIX

SUPPLEMENT

MANUFACTURE OF PAPER NAPKINS

By J. GIGLER

The increased use of paper napkins in recent years has placed them in a position of prominence among converted paper products, and has made necessary the manufacture of improved paper stock to meet the exacting requirements of the converting machines.

Napkin stock is made on machines suited to this type of paper in basis weights from 12 to 25 pounds in various pastel shades as well as pure white. Most napkins are now made from "machine creped" tissue, also known as "one process crepe". The paper is semi-creped on the paper machine in order to provide sufficient stretch and properly receive the embossing treatment applied in napkin conversion.

Another type of napkin stock, known as "two process" or "genuine" crepe, is produced first on a suitable machine in the paper mill, usually a Yankee, and then given a subsequent water crepe in a separate operation on a creping machine. Two process creped napkin stock is naturally a more expensive sheet but has a higher degree of crepe, producing added softness and absorbency.

Napkins are folded in various ways, depending somewhat upon the manner in which they are to be used. If they are to be placed in dispensers, they must be folded to the proper size to fit the particular fixture, and in such a way that they present a tuck that can be grasped with the fingers for removing them. Quarter-fold napkins are folded twice so that the folded napkin is a square, one-quarter of the size of the opened napkin. These napkins are sometimes folded again diagonally and are then known as Triangle-fold.

The Camas Mill Napkin Department is equipped with nine napkin machines, among which are two "fixture-fold" machines, so called because the napkins produced are used in dispensing fixtures commonly seen on lunch counters, at soda fountains and in restaurants. Napkins for these fixtures are made in the 10" x 13½" Junior and 13½" x 13½" Senior sizes.

Fixture-fold machines produce napkins from two parent rolls. One girl tends each machine, removes the automatically counted packs of 125 napkins, and using a foot press, places a tight paper band around the

pack. Four of these units are packed in a carton and the cartons in turn are packed in corrugated shipping cases.

One of the embossing machines produces a $13\frac{1}{2}" \times 13\frac{1}{2}"$ napkin from a single parent roll and is equipped to handle paper in basis weights ranging from $12\frac{1}{2}$ to 25 pounds. Embossing produces a softer texture napkin of distinctive design and is accomplished by running the sheet between a raised-design steel roll and a hard wound paper roll, exactly as described in the manufacture of embossed paper towels earlier in this chapter. Napkins produced on this machine are also paper banded in packages of 125.

Another embossing machine is interchangeable between $13\frac{1}{2}" \times 18"$, $13\frac{1}{2}" \times 13\frac{1}{2}"$ quarter-fold and eighth-fold napkins. This machine also handles paper in basis weights from $12\frac{1}{2}$ to 25 pounds and produces napkins which are also paper banded.

The ribbon-fold machine also produces $13" \times 13"$ or $13\frac{1}{2}" \times 13\frac{1}{2}"$ quarter-fold napkins. Raw stock is fed from two parent rolls making quarter-fold on one side and $2" \times 6\frac{3}{4}"$ ribbon-fold on the other. The ribbon fold napkins have a special type of fold for narrow dispensers and they are packed 500 to a box and 20 boxes to a case. These napkins, when opened, are $11" \times 13\frac{1}{2}"$. Quarter-fold napkins made on this vacuum machine are put up in presses, 1000 in a paper wrapped package, 10 packages to a case.

The largest machine in the plant is a flat napkin cutter, which can handle 25 rolls 55 inches wide at one time. By means of slitters and a shear cut cylinder knife, napkins of standard sizes $13" \times 13"$ and $13\frac{1}{2}" \times 13\frac{1}{2}"$ are produced. These are packed flat and sold to customers who fold them any way they choose. This cutter, which is similar to those in the Finishing Rooms, also produces tray covers in various standard sizes such as $13" \times 17"$ and $15" \times 20"$.

Triangle-fold napkins are made from two-process crepe, on a triangle-fold machine. The napkins are press packed in units of 500 with 20 packs to a case.

A very versatile piece of equipment is the modern vacuum feed machine upon which can be made fixture-fold and quarter-fold napkins, either plain or embossed and the napkins from this machine are paper banded or wrapped in a transparent wrapper. The quarter-fold napkins are made in sizes $12" \times 12"$ and $13\frac{1}{2}" \times 13\frac{1}{2}"$ and the fixture-fold in sizes $10" \times 13\frac{1}{2}"$ and $13\frac{1}{2}" \times 13\frac{1}{2}"$ in any basis weight from $12\frac{1}{2}$ to 25 pounds. Two rolls of parent stock are used simultaneously.

CHAPTER XX

MANUFACTURE OF PAPER TWINE

By J. W. DUVAL

The paper twine industry dates back about 25 years. In its early years it did not prove particularly successful and expanded slowly. In the past ten years the technique of twisting and the application of special chemical treatments have produced a wide variety of styles, sizes and colors of paper twine supplying a highly diversified market. In a great many instances, the paper product has proven itself superior to cotton, jute and sisal twines. At Camas, the industry started some ten years ago with one small machine making twine for shopping bag handles only and has steadily grown until the plant is now able to manufacture 4,000 pounds of twine per day in dozens of different grades. New grades are being continually developed to meet new demands.

Process of Manufacture

Paper twine is made by twisting tightly together one or several narrow continuous strips of paper, usually Kraft. The paper used must have special properties of strength, pliability, sizing and finish in order to produce a twine in high speed twisting machines that will properly stand up under the conditions of use it is intended for. The size of the finished twine is controlled by the tightness of the twist, basis weight of paper and the width of the strips.

The twisting is done with special types of machinery, a number of strands being simultaneously formed on the same machine and wound onto separate spools. The twisting heads are individually motor driven. One machine has 50 motors turning out 260 spools of twine a day.

Immediately after twisting it is necessary to take the twine off the spools and place it under strain to season in the air, otherwise the twine will tend to untwist. Usually after 48 hours seasoning, the twine is properly cured and is then wound or cut into lengths for baling and shipment.

The paper must be softened first in order to secure a tight permanent twist. In the early days this was accomplished with water alone, with the result that the twine in use would dry out, becoming harsh and brittle, and would dry crooked. As much as 20% water was used, resulting in a shrinkage loss to the consumer of as high as 35 pounds per bale. Nowadays

special softening compounds are used producing a twine of permanent pliability and with substantially no loss due to moisture shrinkage. Where a hard tightly twisted twine is required, as for shopping bag handles, a special glue sizing treatment is applied. Dyes may be added to the treating solutions to produce twines in practically any color. Special waterproofing solutions are used for grades designed for outdoor exposure.

Some of the Products Manufactured

Paper twine is generally preferred for tying wool because sisal, jute or cotton twine fibers have a tendency to come off in the wool. They will not wash out and in dyeing do not color the same as wool fibers. This trouble does not occur with paper twine.

The first paper twine for this purpose was a harsh hard twine almost impossible to tie into a knot that would hold. It would kink, open up and catch the wool between the strands of twine. This has been corrected by making the twine more pliable, using a special formula for softening.

Wool twine is made in one ply from a treated paper $2\frac{1}{4}$ inches wide, 44 pounds basis weight, also in four ply, consisting of four rolls twisted separately, then combined together on a plying machine. Single ply appears to be preferred in some localities and four ply in others. California, for example, uses practically all one ply, Eastern States prefer four ply, and Texas and other Middle South States use principally one ply and some four ply. This product is packed in $8\frac{1}{2}$ foot cut lengths, 10,000 strings to a bale.

To obtain some idea of the existing and potential market for wool twine, consider that there are about 57 million sheep in the United States. Nearly two million pounds of twine annually would be required to take care of all this wool, equivalent to 57 carloads of paper; no small item. Nearly 20 billion feet of twine.

Special twine for shopping bag handles comprises one of our important products. It is used at Camas and by several other shopping bag manufacturers on the Pacific Coast. This twine requires a special treatment to produce a hard permanent twist able to stand considerable abuse and free from tendency to annoying warping and crookedness characteristic of early manufacture where water alone was used for softening. The use of a twine that lays straight speeds up the manufacture of shopping bags considerably.

The size of twine made at Camas for various uses ranges from the fine one-ply tying twine up to heavy cord one inch in diameter twisted from about ten rolls of Kraft 6 inches wide.

Some twisted cellophane twine is made although the volume of this item is small compared to the Kraft twines.

Seating cord is a heavy twine used for woven chair seats, and is an item on which considerable tonnage has developed. This is usually a loosely twisted cord made from 3-inch 60-pound Kraft. Tests have shown that chair seats made from paper twine have an exceptionally long life. This product is also made in variegated colors by applying a colored streak about three-eighths inch wide to the paper strip. After twisting, the cord will show colored in some places and plain in others, and after weaving and varnishing, makes a chair of very pleasing appearance.

Considerable quantities of five and six-ply paper twines are used by paper mills where it is very much preferred as it eliminates the danger of sisal or jute fibers getting into the beaters to cause calender cuts in the paper.

Special grades of two and three-ply twines in red and blue have been developed for tying ham and bacon. These replace cotton twines formerly used for this purpose and are proving very successful.

Another article of manufacture is a garden twine in one ply made from a 1-inch roll of paper, waterproofed and colored if desired, for general garden use, tying plants, stringing peas and beans, etc. This lightweight twine in various colors is widely used by stores in parcel tying. Department stores, particularly, use considerable quantities of this item.

Paper twine is replacing cotton twine for stringing hops as it does not stretch or sag as much, also the damaging mold that is prevalent in hop growing will form in cotton twine but not in waterproof hop twine. Hop yards strung with paper twine have gone through a season without loss of a single hill. Samples of this twine exposed to the weather for nine months were found to have lost only 2% of their original strength.

Another interesting recent development has been the use of paper twine in candy suckers. The ends of the twine are looped and imbedded in the candy when it is made, eliminating the danger of injury to children occurring often with the old style wooden sticks.

There has been developed an open mesh visible bag woven from twine and designed for such farm products as unshelled peas, onions and oranges. Colors are used to enhance the appearance of the product. Paper twine is preferred to cotton or jute for these bags as it is smooth, whereas cotton or jute is fuzzy, reducing visibility as much as 50 percent. This has developed into quite an item, in fact, there is one plant in the East that makes nothing but bags of this type from paper twine.

Paper twine is used in upholstering both furniture and automobiles. In furniture it is used as a beading around the backs of davenports, in seat cushions, etc., under the fabric. Twine for automobile upholstering is made by a special process. A web of paper five feet wide twisted into a cord goes through an ironing machine where it is subjected to a pressure of eight tons and is reduced to a very compact cord, rectangular in cross section about $\frac{3}{8}$ inches by $\frac{5}{8}$ inches. This twine is inserted securely between strips of steel which are welded to the car body. The upholstery can then be fastened by nailing through into the paper-filled groove. This type of fastening is superior to wood or fiber formerly used, as it can be easily formed or bent, will not split, warp or shrink and the nails stay tight.

Paper cord is now being used to replace cotton cord for clothes lines and is proving very successful in this field.

This discussion will give some idea of the variety of twine products now listed as standard items and some idea of the diversified market served by this Camas industry. The paper twine business will continue to expand with improved machinery and new methods of processing. Manufacturers are always alert to new fields of application and methods of making twine to meet the requirements of new demands. Tremendous inroads have been made in fields hitherto considered inviolate by cotton, sisal and jute twines. This is good news to paper makers, as every yard of cotton twine replaced by paper twine means a boost for the paper industry.

CHAPTER XXI

PRINTING

By W. E. LAMBERT

PART I — DEVELOPMENT OF THE ART

History of Printing

Printing through the medium of little bits of metal has given voice to endless thoughts and words that might never have been heard. Those metal bits of type do not speak to one individual, but they give the message to the millions who can read. Not just one language, not one tongue, but all languages, all tongues, speak through those bits of metal with a force that no other power can give. Before the advent of movable types or printing, before the time of Gutenberg, feeble were the attempts to give voice to thoughts and words. Some could write the words, and few of the many then on the earth could read what was written.

Ignorance was rife, simply because there was not the means at hand to multiply the printed word, to give voice to the thoughts then being expressed. Many secrets of the past are buried only because there was no printing to help preserve them for the future. Happily, this is now past history. Printing as is now known came to the rescue of humanity and with its birth, the world and civilization progressed more in the 400 or 500 years that followed than in all its previous history.

Some historians tell us that in the eleventh century, the Chinese used the principle of printing with separate blocks or type, but their discovery of typography did not then represent a step in the progress of the Art. Pi Sheng has been given credit for showing the way to printing with movable types in China at this time, but there are so many characters in what in Chinese corresponds to an alphabet, that there was little that was labor saving in his invention, so it was not generally adopted and the knowledge that the Chinese had invented typography did not reach Europe until after it had been invented independently there.

Prior to 1450, what printing there was, was either done by hand or with the wording or illustrations cut on blocks of wood in a very crude fashion. Most of the work, however, was done by men who were known as illuminators, and with the aid of a large feather pen and colored inks, would print by hand on separate sheets of vellum or whatever was used for paper. Practically all of this work was written in Latin.

It was quite by accident that Johann Gutenberg of Mainz, Germany,

in 1450, invented movable types. He had been trying to fit a title to a small book that he was printing and had printed it by hand first on a piece of paper, but as it did not quite suit him, he began cutting it here and there between words, so he could rearrange them into more lines. After cutting this strip a number of times he found he had some of the separate letters cut from the words, making it possible to move them around at will. The thought then came that if he made them all separate he could build his words and sentences to fit the sheet and at the same time he would not have to cut a new block every time he wanted new words. And so he set about cutting separate letters on small blocks, and that one thought revolutionized the art of printing.

The First Book

The first work to be produced by this new method was the Gutenberg Bible in 1455. It was known as the 42-line Vulgate Bible, because there are 42 lines to the column and the language used was the "Vulgar" Latin, or the ordinary Latin of the time as differentiated from the old Latin. It was the language of most writers and was generally understood by the average scholar. This book is not only the first book printed, but it stands out as the best printed book today.

It is in three volumes and was originally purchased from Gutenberg by the Benedictine Monastery of St. Blasins in Germany. It rested here for more than 300 years when it became the property of the Monastery of St. Paul in Austria. After the World War, the Monastery had to sell the book to obtain food. Dr. Otto H. L. Vollbehr purchased it for some \$300,000.00. Then came financial difficulties to Vollbehr, and in turn the Bible became the property of the United States, Congress appropriating money for the purpose of securing it. The value of these three volumes today is placed at above one million dollars, and in a typographical and artistic sense they are priceless.

A copy of the Gutenberg Bible, valued in excess of \$50,000.00, can be seen at the Huntington Library in Pasadena, California. Fig. 122 shows a page from this famous book.

Early Printing in Europe

Augsburg, Germany, is best known in history through its "Augsburg Confession," which associates it with Martin Luther and the beginning of Protestantism. At one time it became known as the most important printing center in Europe.

France took up printing in 1458, after Charles VII of France had sent Nicolaus Jenson to Mainz, Germany, to secretly learn the new art.

century, numerous cities and towns possessed presses and type. Jenssen, a Frenchman by birth, previously mentioned, became one of the foremost printers of Venice, and his work excelled in beauty of design and proportion. Jenssen's Roman types have been the accepted models for Roman letters ever since he made them, and though they have been repeatedly copied in our own day, they have never been equalled.

Spain, next to follow, began printing in 1468. This was at the City of Barcelona, and the printer's name was John Gherling. However, there is some difference of opinion by historians as to this being the exact date. Some believe that 1475 was the correct year.

The Dutch, or the Netherlands, as Holland and Belgium were then known, took up the art in about 1471. Here it was that the "Coster Legend," with regard to printing, was originated. The background of this Legend is that one Janzoon Coster, a Dutch printer, prior to 1440, not only had invented the principle of movable type, but was making use of it, and that one of his workmen had later gone to Mainz and went to work for Gutenberg, who, it was claimed, took the credit for being the inventor. However, it has been proved almost beyond a doubt, that this was not the case and Gutenberg is considered the first to use the principle.

William Caxton was responsible for England's first printing. This was December 13, 1476, at Westminster. Caxton had done printing before this at Cologne, where he had spent some 30 years. England was the first to print in any language other than the Latin. Other distinguished printers of England were Caslon, Baskerville and Morris. Baskerville was a very prominent printer in England between the years of 1750 and 1780, and in 1766 printed the well known "Virgil."

By this time printing was being done in most of the countries of Europe and this brings us now to America.

Early Printing in America

The first printing press in America was set up at Cambridge, Massachusetts, in 1638. A man by the name of Jose Glover, with his wife, had started from England with the outfit, but during the voyage Glover died, leaving the equipment to his wife. After landing in America, Stephen Daye was made manager, and although he had not had previous experience, he was considered the first American printer.

The second press to be used was in 1682 and was owned by William Nuthead. What he first printed and the locality is unknown.

Benjamin Franklin was Pennsylvania's earliest printer, as well as being considered the world's most distinguished printer. Franklin was born in 1706 and at the age of 22 set up a printing office of his own in Boston.

Mass., in 1728.

Kentucky was the first of the territories on the western frontier to boast of a printing press. It was owned by a John Bradford of Virginia, and the publication was called "The Gazette," and was printed at Lexington, "Kentucke," as it was then spelled.

At about 1770, in Boston, Isaiah Thomas became quite a distinguished printer and patriot of Revolutionary days, because of the leading part he took in the political activities of those stirring days. It was "tough sledding" for Thomas during the Revolution, because his paper, "The Massachusetts Spy," was devoted to the interests that were working for American independence, and had a wide influence in molding public opinion. Between 1771 and 1775, several attempts were made by the government to suppress it, and on April 16, 1775, he moved his presses and type from Boston and set them up in Worcester, Mass. He not only owned his own printing office in Worcester, but he also erected a paper mill there and set up a bindery, so was able to produce a book in its entirety. He takes a high place among the most talented and patriotic men of Revolutionary days in America—with Paul Revere, the engraver; with Benjamin Franklin, printer and master of many things; with John Dunlap, printer of the Declaration of Independence, and many other men of high principle and accomplishment who lived in America at that time and worked for the independence of the Colonies.

From 1728 to 1833, different localities followed closely one after another in the establishing of printing plants, so that, at the end of this period, printing was being done in most of the states of the Union.

Development of Printing on the Pacific Coast

California and Oregon up to this time had no printing plants. It is generally believed that about 1833, California had its first printer, although his name is unknown. In 1834, a Mexican by the name of Augustia Vincente Zamarano, began printing some sort of manifesto. Later, two men, Rev. Walter Cotton, chaplain of the "Frigate Congress," assisted by Robert Semple, started a small newspaper called "The Alta-California." This was on August 15, 1846, although Oregon had already started a newspaper at Oregon City in February of the same year and, of course, this was the first newspaper printed west of the Missouri river.

The first book printed west of the Rocky Mountains was in 1839. The Whitman and Spalding Missions were given a press by a mission in Honolulu, and with the press came a man by the name of Hall. Within the year he had printed the "Nez-Perces First Book," a lexicon and grammar in the Nez-Perce language. This was imprinted "Clearwater, Mission Press, 1839." Other books followed in 1840, 1842 and 1845 from

this same mission, and some were printed in the language of the Spokane Indians.

The second period of printing in this territory began in 1850, near the end of that year, the "Western Star" was started in Milwaukie and the "Oregonian" in Portland. Both were weeklies. The printing press used for the "Oregonian," an old Ramage press, was the same press as used to print the first newspaper in California, "The Alta-California." This same press had quite a distinguished career in printing the first newspapers in various parts of the Northwest. On it was printed the first newspaper north of the Columbia, "The Columbian" at Vancouver, Washington, in 1852. Some historians differ on the location of this publication. Some give Olympia as the first location. During its later transfers, it was used to print the first newspaper at Seattle, the first paper at Walla Walla, and the first newspaper in Idaho. It is now in the University of Washington Museum at Seattle.

Up to this time eight states in the West were not doing printing yet, but by 1867, seven of the eight had joined the ranks, and Wyoming was the last to be represented by the printed word. It was in this year that three newspapers were started. From then on, of course, printing plants became more and more numerous until today, printing ranks as one of the leading industries of the country.

PART II — PRINTING TECHNIQUE

To cover printing in all its phases would require many chapters, so what follows must necessarily be only the highlights of this important art—for printing is an art. This is evident on every hand. There is hardly a magazine or publication today that does not have colored inserts equal to oil or water color paintings. This result is largely due to the skill and artistic ability of the pressman or printer handling the plates they are printed from.

Printing has probably done more in the last 500 years toward the enlightenment of the world than any other one thing.

So, *Printing* is the *Inseparable Companion* of *Achievement*. Take the first letter of the main words of that sentence and they spell *Pica*. This word is used for denoting a measure. A printer does not use inches as a measure, but measures by points. One pica is 12 points, and 6 picas equals one inch, or 72 points. The point system was put in use at about the time of the Civil War. All type sizes run by points and are made in many sizes, such as 8, 10, 12, 24, 36, 48, etc., points.

Composition

Hand composition is an art or trade in itself. It is not only a highly skilled trade, but requires visualization, ingenuity, originality, good

spelling, and a general knowledge of the proper use of the English language. Type is hand set today in practically the same manner as was done 300 years ago. The principal difference is in the style of composition and the style of type faces. However, we have today type faces that are almost the same as when first originated. Bodoni, Baskerville, Jenssen, Garamond, Caslon, are some of the better known type faces used today that have not made any particular change.

It was not until after the middle of the nineteenth century that machine composition gained headway. Along about 1870, Mergenthaler came out with a machine that startled the world. With it one could sit down to a keyboard like a typewriter and by simply typing the copy, metal type was assembled as it was written. Mergenthaler, however, was not the original inventor of this machine. Three young men earlier in the century had set about to make a machine that would set type. After a number of years, and at a great deal of expense, disappointments and failures, one of the men eventually succeeded in getting Mergenthaler interested in his invention, who in turn agreed to finance the project. However, this fell through, but Mergenthaler never let the idea get away from him, and after several years of experimentation "The Mergenthaler Linotype" was the result.

At about the same time these young men were working on their machine, another young man was working on a similar machine, although it was very much more complicated. It had some 1800 to 2000 working parts. In fact, it was so complicated that it was not practical and the inventor eventually lost his mind. One of the attorneys who had been employed to get out patents also lost his mind.

The Linotype, as we know it today, is a very efficient machine and has many improvements over former machines. There are also on the market a number of other typesetting machines, such as Intertype, Ludlow and Monotype.

Here in the Camas plant most of our printing is done from electrotypes or rubber plates and what typesetting is required is done by hand. The forms are made up according to copy and the mats are made and sent to the plate foundry to have the plates cast.

We have about 148 different fonts of type with about 57 different type faces. This is approximately 136,000 to 137,000 separate pieces of type, not counting the many thousands of pieces of leads and slugs that have to be used for filling in a form.

Printing Processes

There are three distinct processes of printing, as follows:

1. Relief surface, or Letterpress.
2. Plane surface, or Lithograph.
3. Intaglio, or Rotogravure.

The relief, or letterpress, prints from type or cuts raised so that the ink is taken from the raised portion.

The plane, or lithograph, is done with plates that are perfectly smooth and the ink is made to take where wanted by the action of the water and grease principle. This will be explained later under plates. In this process there are two methods, Direct and Offset. (Fig. 123) In direct lithography

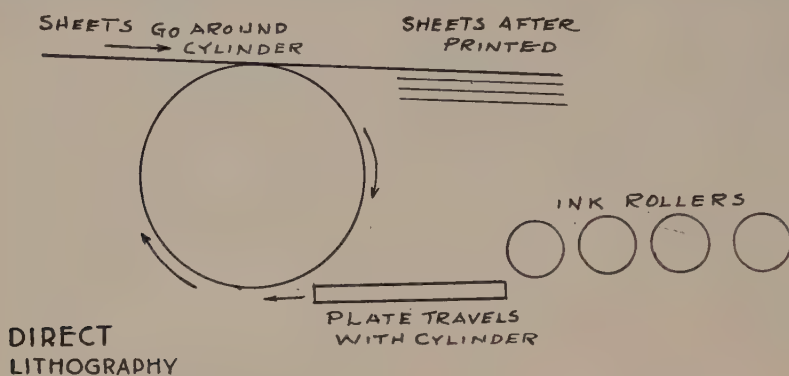


Fig. 123. Direct Lithography

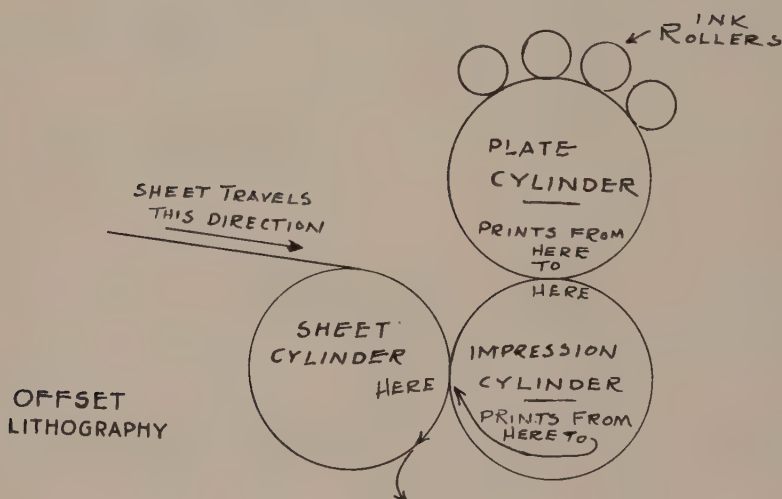


Fig. 124. Offset Lithography

the plate comes in contact with the sheet of paper to be printed, while with

the offset the ink is placed on the plate and then transferred to a rubber blanket stretched around the blanket cylinder, where it is again transferred to the paper from the rubber blanket. (Fig. 124.)

The Intaglio, or Rotogravure, is directly opposite to the relief or letterpress printing. Instead of the type or printing portion being raised, it is a depression in the plate. (Fig. 125.)

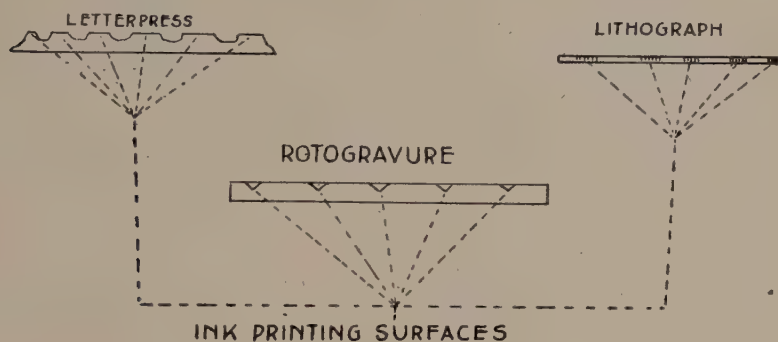


Fig. 125

In letterpress the rollers place the ink on the raised portions which are then put in contact with the sheet. In Rotogravure the plate travels through the ink and the ink on the raised portions is wiped off by a blade. This leaves ink in the recessed portions of the plate, where, in coming in contact with the sheet it is immediately taken up by the paper. In this process it is very essential to have the ink very thin, as it must penetrate the sheet just as soon as it comes in contact with it. With this process there is greater fidelity of tone and a softer gradation between the high-lights and solids than in the relief.

In letterpress printing, the plates used are wood cuts, zincs, electros, stereotypes, and rubber plates. A wood cut is usually cut by hand. The zincs, or zinc etching, must first have the drawing made of the design to be printed, and this is usually made one-fifth or one-third larger, or twice the size needed. This is for the purpose of eliminating to a great extent any defects in the cut, which would show up if made the same size as wanted. Thus the defects are reduced in proportion.

Photo-Engraving

The next step is to photograph the drawing. In color work, filters are used to separate the colors, which are made on separate plates, one for each color to be used in printing the design. The film or the negative is stripped off the glass, reversed, and placed between two other sheets of glass so that when exposed to the zinc, the zinc will be a negative instead

of positive. If the zinc were positive, then the printed work would become negative. So the film must be reversed in order to make the zinc negative. The zinc is then sensitized, exposed and then fixed, after which it is rolled up with ink and a powder, in most cases "Dragon's Blood," is spread on the surface. It is then burned in to resist acid and placed in the acid (nitric) and allowed to etch slightly. This powdering, burning in and etching is repeated four or five times, each time being called a bite. Usually four or five bites are sufficient for the ordinary zinc plate. It is then touched up by hand with an engraving tool and afterwards mounted on wood. All cuts or type are made type high, which is .918". Engravings are sometimes made by etching polished brass plates. These are known as "brasses" and their manufacture and application are similar to zincs except that they have a longer life.

Electrotypes

Electros are made by taking this zinc and moulding it in wax, where, by an electroplating process, a shell is made and the metal is poured into this shell, making a metal plate about 3/16 inch thick. This metal is composed of approximately 80 percent lead, 13 percent tin, and 7 percent antimony. In running large amount of paper, it is more desirable to use electros than zincs. Electros are much cheaper than zincs, and when worn out can be replaced by having the zinc in its original state, while if the zinc were used until worn out the replacement would be a great deal more expensive.

Stereotypes

Stereotypes are made by first having a mat made from the cut or type form. This mat is composed of several sheets of blotter and tissue paper pasted together, moistened and placed on the form and then beat in with a brush. This is called the wet mat. There are prepared mats on the market which only have to be dampened before using. It is then covered over with a thick drying felt and placed in the steam table where pressure is applied while drying. It is left in the steam table about 10 minutes, after which it is removed from the form and is sent to the plate foundry where it is placed in a casting box (either curved or flat) and the hot metal is poured in on top of the mat. When the metal has set long enough to cool, it is taken out and is now a perfect mold of the original cut or type. Stereotypes are nickle plated to harden the wearing surfaces and increase the life of the plate.

Litho Plates

The lithograph plate is made by first making a number of proofs from the zinc etching used as an original. These proofs are pulled on transfer

paper, or paper that has been coated with a solution of flour, water, glycerine and brown sugar and allowed to dry until ready to use. These proofs are then assembled on the zinc, which is to be put on the press to print from, in their proper position and then moistened and put through a press with high pressure, leaving the ink from the transfer sheets on the zinc. This is then treated chemically to fix the image to the zinc plate, after which it is ready to use.

Process Color Work

Process color work is made up of three or four colors, with special process inks, the colors usually following in this order—yellow, red and blue in the three-color work, and with black added in four-color work. In four-color work the black is sometimes run second, which allows for the using of black as the key color for register. In process color work the three primary colors, yellow, red and blue, must be used, and from these three colors we get the secondary colors, or violet, orange and green. Primary and secondary colors blended together produce tertiary colors, which are citron, olive and russett. All of the primary colors must be transparent for the reason that yellow and red combined gives orange, and yellow and blue combined gives green, etc.

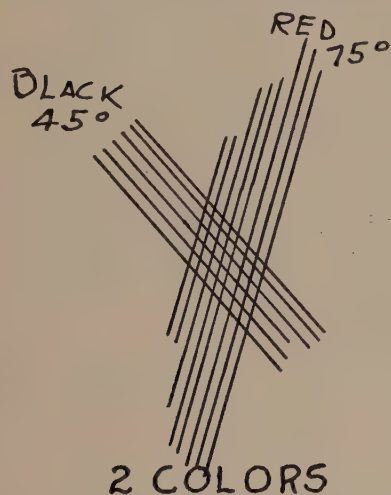
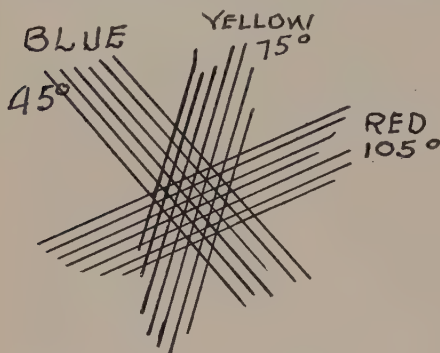


Fig. 126.
Two Colors

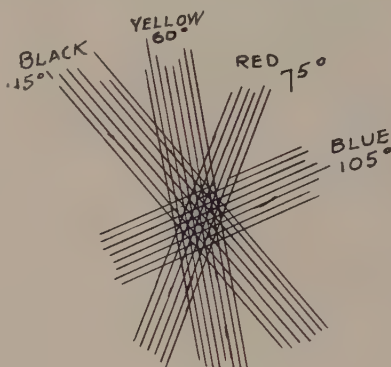
The plates used are a little different than the ordinary printing plates in that the screen in each color will always be the same, on the same slant, for the same color. For instance, in two-color work you would have black and red. The black is in the screen at a 45 degree angle, while the red plate has the screen or the lines running at an angle of 75 degrees. (Fig. 126.) There is usually a distance of thirty degrees between each color. The order

of colors in three-color work is blue at 45 degrees, yellow at 75 degrees, and red at 105 degrees. (Fig. 127.) In four-color work, the black is again at 45 degrees, the red at 75 degrees, the blue at 105 degrees, and in order to get the fourth color in, yellow is placed at the 60 degree angle. (Fig. 128.) This is necessary for the reason that all lines cross each other at different angles, making dots, or a series of dots, coming in such a way as not to overlap entirely, the one on the other.



THREE COLORS

Fig. 127. Three Colors



FOUR COLORS

Fig. 128. Four Colors

In process color work, it is necessary that the pressman running these colors be experienced in handling colors for the reason that any one of these colors not being absolutely right will change the desired effect of the finished work and possibly spoil all of the work that has gone before. He must not only know when he has exactly the right amount of color on, but he must also know about how fast to dry his ink so that the ink will not be absolutely dry before putting on the next color. The slightest change of color in any one of the four will make an altogether different shade of color than that which is desired.

Included in this book are color plates which show the building up of a four-color illustration by successive application of yellow, red, blue and black.

Printing Ink

Printing ink has three requirements: first, body; second, cohesion, which means "long" or "short"; and third, adhesion, which means tack or viscosity. The structure of the ink is made up of three parts: first, vehicle; second, pigment; and third, drier.

Ink Vehicle

The vehicle is usually made up of different grades of varnishes. The

*The following Colored
Section is inserted to show how a four
color process job is printed. In this illus-
tration the yellow is printed first,
red second, black third
and blue last.*



PLATES BY COURTESY
SWEENEY, STRAUB & DIMM
PORTLAND, OREGON







PLATES BY COURTESY
SWEENEY, STRAUB & DIMM
PORTLAND, OREGON



PLATES BY COURTESY
SWEENEY, STRAUB & DIMM
PORTLAND, OREGON



varnish is known as long or short. The long varnish comes in about five grades, ranging from 00000 varnish, which is the thinnest and most commonly used in letterpress printing as a reducer, to 0000, etc., on down to 0. Short or heavy varnish runs from 1 to 8, inclusive. No. 8 is the heaviest and is comparable to very thick molasses. The shorter varnishes are most commonly used in lithograph printing, while the long varnishes are used in the letterpress or relief printing. The difference in the body or viscosity of these varnishes is due to the different lengths of time they are boiled. They are of a linseed oil base, and each grade must be boiled a certain length of time under certain temperature conditions.

Pigments

The pigments are composed of dry colors or dyes. These may be divided into two classes, the inorganic pigment dyes and organic lake dyes. The dry colors are ground into the varnishes with an ink mill especially designed for that purpose.

Driers

The driers are used for the sole purpose of causing the ink to dry faster. There are a number of different driers that can be used, the most common being the Cobalt paste driers and the Japan driers. The Cobalt drier is a very fast, hard drier and is used mostly for dark colored inks. The paste drier is preferable for light colored inks. The ink manufacturer usually puts a small amount of drier in the ink when it is manufactured, but when it is used on the job, the pressman must determine how it is used because of varying conditions and may have to add additional drier.

Care must be exercised on the part of the man using these driers. In running labels, where four, five or six colors are to be used, with gold to be printed as a last color, it is absolutely essential that the colors that cover other colors, do not become crystallized, thereby causing considerable lost time and extra cost in eliminating the gloss due to this crystallization. Sometimes the work is a total loss.

In running color work where from three to six colors are used, the pressman must necessarily know how to run these colors, about how fast each color must dry, how much or how little must be put on the sheet, and above all, he must be able to visualize the finished work each time another color goes on. This requires keen judgement and long experience. With one or two colors this is not so important.

Ink Body

A different body ink is required for each different kind of paper such as bond, label, newsprint, etc., For instance, bond papers require

a special bond ink which must have a very thick and heavy body for the reason that this grade of paper has a hard surface and if a light ink such as newsprint ink were used the ink would not take to the sheet. The same is true of label paper which requires a specially ground ink softer in body than the bond inks. Newsprint requires a very soft oily ink for the reason that the surface is soft and very absorbent.

Different kinds of presses require different bodies of ink. For instance, a slow running flatbed press could use an ink with much more body than a high speed rotary, which would take an ink softer in body and mixed with certain oils to give it faster penetration.

Atmospheric Variation

Atmospheric conditions greatly affect ink, paper, makeready, rollers and nearly all operations of printing. Ink run in too cold a room becomes very sticky and does not spread and cover the plates as it should. The same is true of the rollers. They shrink in low temperatures until they will not touch the plates. Then the rollers must be reset, and after the air becomes warm again, they will swell up to their normal size, and if not watched very closely, will start heating from friction, causing them to melt immediately. Paper gathering moisture from cold damp air has a tendency to swell and expand on the edges so that when run over the press, wrinkles will form in the sheet. The makeready, being made up of paper pressed on a cylinder, naturally absorbs moisture when the atmosphere is cold and damp. It also affects the original makeup to the extent that a sheet must be taken from the packing when it swells. Then when the temperature rises again, this sheet must be replaced to make up the original thickness of the makeready.

Inks and their handling is almost an art in itself and should be done by someone who has had a great deal of experience.

Rollers

The first composition press roller was used at Cambridge, England, in 1816. These rollers were introduced in France in 1820, Germany 1823, and in the United States in 1826, the first user in this country being Daniel Fanshaw of New York City. The principal difference between the old glue and molasses roller and the rollers of today, is due to the use of glycerine, which greatly increased their durability. Glue and molasses rollers dried and shrunk rapidly, but this tendency was overcome by the substitution of glycerine for molasses. The principal ingredients of roller composition today are glue and glycerine. Glycerine must be free from acid or alkali. Glue must come up to certain standards of viscosity and tensile strength. Composition rollers that are poor in quality produce

mottled and lifeless impressions. If the rollers are hard and do not have sufficient suction, excessive impression is necessary. This not only causes wear on plates, but causes the packing to slip and may produce wrinkled sheets.

Setting of rollers is very important in regard to being set either too high or too low. If too high, they do not come in contact with the ink plate, which distributes the ink to all rollers, and also do not spread ink on the printing plate. In this event, the printing would not show up. On the other hand, if the rollers were too low, they would not only cause friction in the rollers themselves, which would eventually ruin them, but would press the ink into the many depressions in the plate, causing the printed work to look smeary.

Weather conditions greatly affect rollers. On a cold, damp morning the moisture in the air may cause the rollers to shrink slightly. Then they must be reset and later in the day, after running awhile when the temperature of the room has risen, the rollers will expand to their original size and if not again reset, poor work will result. As stated before, friction is caused and it would not be long before the rollers would melt.

Rollers, like ink, must necessarily be made for the particular type of press they are used for. Letterpress rollers, for instance, are made from the materials mentioned previously. They are not intended for high speed work. For a high-speed rotary press of the letterpress type, a non-melt roller is used, which is of similar material, but will not melt under speed. Also there is a rubber roller on the market today that compares favorably with the composition roller, yet stands up well under high speeds. For the offset presses, leather and rubber rolls are used. Litho inks, being so much heavier in body, makes it necessary to use a roller that will break up the ink as well as repel the water that is used for dampening the plate.

A recent improvement in the field of rubber rollers has been the introduction of synthetic rubber of the Duprene type. Although of higher initial cost, these rollers have a longer life than ordinary rubber rollers, as they are much more resistant to the ageing effect of oil inks.

Rubber Plates

A number of years ago, many printers realized that there were certain limitations to letterpress printing and they set about to make it more elastic. This, of course, brought to mind rubber, and so they began taking old offset blankets or any other sheet of rubber and glueing them to wooden blocks and then making tint plates, engraving by hand simple designs on them.

These plates were necessarily very crude, but they were able to obtain effects that previously were thought impossible.

However, the idea was generally discarded, because there were so many inaccuracies in thickness, regardless of the care taken in making the plates. The rubber that was being made at that time had no oil resistance and the result was that the oils in the ink deteriorated the rubber, and of course, caused failure of the plates.

At that time the causes were never investigated or considered, the thought being that they were no good.

From five to ten years ago many rubber companies began advertising "oil proof" rubber because, with their vast resources for chemical research, they had perfected a compound that would resist oil as well as abrasion. It is not uncommon to have a plate last for one million impressions today, where at first ten thousand was considered a good run.

Today, rubber plates are being manufactured for a great many lines of work. They are particularly suited to cover stocks, embossed papers, cellophane, glassine, metallic papers, glass, tin, bags, etc., and ink coverage can be maintained without mottle and with about 40 percent less ink.

Any type of ink can be used with rubber plates, although inks containing chemicals that are rubber solvents will in time destroy the plates.

Most rubber printing plates today are moulded in a steam or electric vulcanizer, from mats made of Bakelite. This material is a phenolic compound, although there are many other materials used for the same purpose.

The plate can then be mounted on various kinds of metal or patent bases, curved for rotary presses, or blocked type high for locking in a chase.

The method for mounting is to use a double sided adhesive which is placed between the rubber plate and the metal it is mounted on.

Briefly, the method used is as follows:

First, a mat is made by using the Bakelite which comes in sheets.

A piece large enough to cover the plate or whatever is used as a master, is cut and placed on the cut. It is then put in the press and allowed to remain for eight to ten minutes under a pressure of 750 pounds per square inch at approximately 312 degrees Fahrenheit. The mold is then removed and it is now ready to be used for moulding the rubber.

This time a piece of rubber is cut to cover the Bakelite matrix which has just been made and this is also put in the press and the pressure again applied for twelve to fifteen minutes at a temperature of 312 degrees Fahrenheit. Matrix and rubber are then removed and the rubber peeled from the mat, and after trimming and testing for thickness it is ready for use.

When the job is completed the plates can be peeled from the mounting and put away for future use.

Two very important items in running rubber plates are the roller setting and impression. The setting of rollers should be carefully done as rollers which are riding the plate too hard will ruin it in a very short time. Likewise, if the impression is too hard, the plates will wear very fast and become worthless much sooner than they should. The rollers should just touch the plate and the plate should just touch the sheet, or have a "kiss" impression.

Equipment has recently been installed at Camas for making rubber plates and the presses are gradually being changed over to adapt them to this newer type of printing plate.

Presses

A great many kinds of presses are made today, platen presses, flatbed, duplex, aniline, rotary, etc., varying in complication of design from the simple bag machine presses to automatic multicolor, self-feeding high-speed precision presses. At Camas we have all told about 30 presses, representing all these types and designed for flexibility, so that we are able to expeditiously handle a wide variety of demands.

And so, today, printing is the great voice of the world, for it is not for the moment a sound, as in radio, that is here for a second and then gone—but it can give voice for all periods of time to come. It has also supplied the key that unlocked the door to the wit and humor of the world as well as to the sober things, the poetry and philosophies.

This is the age of wonders, but none of them can, nor have, approached that of printing as a benefactor, not only to human beings, but to all things that are of the world. It brings joy, pleasure, comfort and beauty to all the world, all people, all places and all things. Wherever there is laughter, where there is beauty, printing will be seen and its presence felt.

CHAPTER XXII

WAREHOUSING AND SHIPPING

By A. W. OLSON

Having followed the flow of raw materials through the various manufacturing units to the beaters and machines and through the finishing and converting operations, we come now to the problem of getting the products out of the mill and into the market. This is just as important a link in the chain as any other phase of mill operation. A shipping department without proper organization and facilities results in delayed shipments, lost or misplaced merchandise, damaged paper and incorrectly filled orders. These things can play havoc with the reputation and efficiency of the entire plant regardless of the amount of technical and operating skill expended in an effort to produce a perfect commodity.

Warehousing and shipping the products of the Camas plant is probably a more complicated operation than is found in the average paper mill, due to the combination of heavy tonnage and variety of products manufactured. In order to give our customers prompt service, we carry a considerable working stock of rolls and converted products in standard grades on hand. This, of course, also has the advantage of keeping grade changes on the paper machines at a minimum. Even in periods of peak demand when the mill is "sold ahead," it is necessary to carry a minimum stock of 1500 tons of paper bags, 40,000 cartons of toilet tissue and towels, and 1500 tons of wrapping paper. In spite of the heavy working stock of these items, none of it is "dead stock" subject to deterioration. It is constantly turning over.

Shipments leave Camas by boat, rail and truck. In normal times most of the mill tonnage is moved by boat to Portland to be transshipped by steamer to Eastern or Western seaboard destinations or to foreign ports, and by rail to mid-continent points.

Some shipments leave the plant by direct rail routing and a relatively small amount is shipped to local points by truck. Normal daily shipments from Camas dock average 400 tons.

Paper from the finishing rooms, bag factory, printing plant or converting plant is transferred to the dock on flat cars handled by electric locomotives on the tramway system. The routing of these cars is handled through a dispatcher's office in the same manner that a regular railroad operates. In this way incoming shipments of equipment and raw material

can be handled by the tramway system along with outgoing paper shipments with a minimum of "dead heading" or hauling of empties.

The Dock

The present dock was built about three years ago. It was specially designed for our requirements and is one of the most modern shipping docks on the Pacific Coast. There is the unusual problem of having to contend with seasonal rises in the Columbia River level of as much as 25 feet, which introduce more complications than a salt water dock, where slips can be raised or lowered according to the tide. To get around this two special Barlow Marine elevators were installed to handle large tonnages quickly, regardless of the river level. They each have a capacity of seven tons at 100 feet per minute, and ten tons when operating at a speed of 60 feet per minute.



Fig. 129. Camas Mill Dock

The dock itself is a three story building, the two lower floors being used for shipping and the top floor for storage. The floor area is 115,000 square feet, providing a storage volume of 1,500,000 cubic feet. The two upper floors are of laminated wood construction with staggered joints, while the lower floor is of concrete, since it is liable to be submerged during high water periods in the river. The floors were designed for a dead loading of 400 pounds per square foot and for the concentrated live loads of fully loaded lift trucks.

The company operates its own river steamer system under the name of the Western Transportation Co. The boats make one round trip each day between Camas and Portland. Paper is shipped on covered steel barges, each having a capacity of 300 tons. The barges are unloaded at Portland docks for transshipment or may be unloaded directly at shipside to the company's coastwise freighters. On the return trip upstream, the barges carry miscellaneous mill supplies such as alum, salt cake, pigments and machinery. While the loaded barges are being towed downstream to Portland, empty ones are being loaded for the next trip.

Cargo Boards

Until about two years ago, paper shipments were loaded mostly by hand trucks from dock to barge and stowed by hand labor in the barge to a height of ten or twelve feet. Unloading at Portland was done by the same hand method. In order to expedite cargo movements and reduce handling costs, the cargo board system and power lift trucks were installed. The lift trucks are gasoline powered and since the dock floors are at the same level as the flat car decks, the trucks can handle the paper directly from flat cars.

A cargo board is about six feet long by three feet wide and built so that the two forks of the lift truck can pick it up and stack it on top of another loaded board on the dock or in the barge. The average weight carried on a board is 1500 pounds. These boards are stacked three high, the head room on the dock having been designed specifically for this arrangement. On arrival at Portland the loaded boards are handled from the barge by trucks in the same manner, eliminating all the old time costly and time consuming hand stowing.

The function of the shipping department is to get out an order as quickly as possible, to check weights of all products for invoicing, to see that the shipment is turned over to the Western Transportation Co. in good condition, and to make sure that all items check exactly with the customer's order as listed on the bill of lading. About 60 percent of our output during periods of normal demand is loaded on cargo boards in the finishing rooms, bag factory or converting plant and handled directly to the dock without intermediate warehousing. The checker at the dock checks the contents of each cargo board with the tally made when the board was loaded and assigns the load to a certain bay on the dock in order that barge loads can be made up for discharging to the best advantage at Portland. As shipments are turned over to the Western Transportation Co. a bill of lading is given them and their checker again goes over the shipment item by item to make sure it is correct as billed. This system of double checking protects both the mill and the carrier, and improves the efficiency of cargo handling by eliminating shipments incorrectly or only partly filled.

CHAPTER XXIII

STEAM

By O. T. DEFIEUX

To steam, and more especially the development of the steam engine, can be attributed one of the most important chapters in the history of civilization. Throughout the machine age steam has continued to be one of the greatest factors of development. At the present time, despite the rapid progress of the internal combustion engine and the intensive development of water power, by far the greater part of the mechanical and electric energy generated for industrial purposes is furnished by steam power plants.

To the student who would make a study of this or any other branch of engineering we recommend that consideration be given to the following statement by Lord Kelvin, one of the world's greatest scientists. "When you can measure what you are speaking about and express it in numbers, then you know something about it. If you cannot do these things, then your knowledge is of the meager and unsatisfactory kind."

Realizing that the study of a course covering the entire pulp and paper industry involves a knowledge of the industrial application of all branches of engineering it is our intention to consider only such fundamentals in respect to this phase of the student's work as will enable him to follow the simpler applications of steam power to the industry as a whole.

Simple Fundamentals and Units of Measurement

Work. Work is the overcoming of resistance through a certain distance. The unit of work is the foot pound. Thus if we raise a body weighing 10 pounds through a distance of 5 feet we have accomplished 50 foot pounds of work.

Power. Power is the rate of doing work. The unit of power is generally expressed as the horse-power. One horse-power is equivalent to 33,000 foot pounds per minute.

Energy. Energy is the capacity of a body for doing work. The unit of energy is therefore the same as that of work, that is, the foot pound. Energy is sometimes classified in respect to the conditions of the body which has the capacity for doing work. Energy stored in a body at rest is generally referred to as potential energy and the energy of a body in

motion, kinetic energy. There are various forms of energy, as for example:

- Muscular energy.
- Electrical energy.
- Chemical energy.
- Heat energy.
- Mechanical energy.

The law of the **Conservation of Energy** states that energy can neither be created nor destroyed. It can be transformed from one kind into another. Some common examples of the transformation of energy are as follows: Muscular to electrical—a person ringing a telephone bell; electrical to chemical—electroplating and the charging of electric storage batteries; chemical to electrical—the discharge from a storage battery or dry-cell; chemical to heat—the combustion of fuels; electrical to mechanical—the electric motor; electrical to heat the electric boiler or the common type of electric heater.

Heat. The usual conception of heat is that it is a form of motion or vibration of the molecules of a body. The more heat a given body has, the faster are these vibrations. It is important that the student be able to differentiate between the quantity and intensity of heat in a body. The quantity of heat in a body is measured in units called the **British thermal unit**, the general abbreviation being B.T.U. One B.T.U. is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. The intensity of heat is measured by the thermometer and is called temperature. Three scales are used to measure temperature, but in general engineering practice the Fahrenheit scale is used. Under normal atmospheric pressure water freezes at 32° F. and boils at 212° F. As heat is a form of energy, and energy in a body is the capacity for doing work, then heat can also be represented in the unit of work, that is, the foot pound. The mechanical equivalent of one B.T.U. equals 778 foot pounds. To enable the student to get a clear conception of this difference between heat quantity and heat intensity and remembering at the same time that heat is a form of energy, we would like to point out the analogy between heat and water. The head of water or the elevation of a waterfall may be compared to the intensity or temperature of heat. The volume of water at a given head is comparable to the quantity or the B.T.U. value of heat. Near the present Bonneville Water Power Development on the Columbia River we have the picturesque Multnomah Falls which has a head many times that being produced by the Bonneville Dam. Even at this higher head the total energy available from Multnomah Falls is insignificant as compared to that available from the lower head development at Bonneville. This is similar to the case of a small body with a high temperature

often having an insignificant **quantity** of heat as compared to an extremely large body at a much lower temperature.

Heat may have either one or two effects upon a body. It may raise its temperature or it may change its state. Heat which raises a temperature of a body is called sensible heat. Heat which changes the state of a body is called latent heat. In Fig. 130 the amount of heat required to change one pound of ice at 32° F. into one pound of steam at 212° F. is plotted.

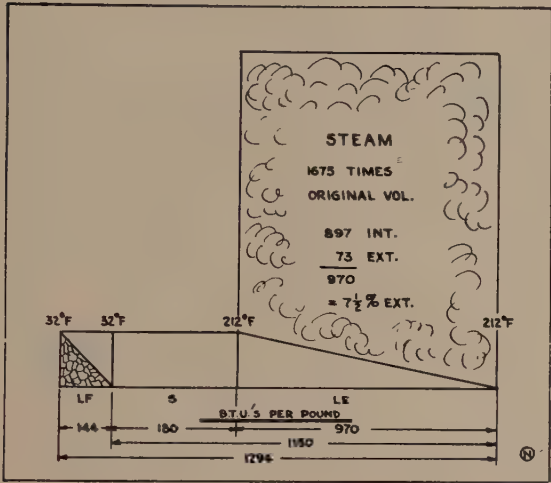


Chart of Latent and
Sensible Heat

Fig. 130

The first application of heat to this pound of ice will cause it to melt, that is, to change its state from a solid to a liquid. When all of the ice has melted we then have a pound of water at the same temperature as the ice originally had, that is, 32° F. It will be noted that 144 units of heat have been required to change the state of this body without changing its temperature. This is an instance of latent heat. The latent heat used to change a body from a solid to a liquid state is called the **latent heat of fusion**. Further application of heat to this pound of water at 32° F. appears as sensible heat and raises the temperature of the water. After 180 units of heat have been absorbed the temperature of the water has been raised to 212° F. Further application of heat appears as latent heat, there being no increase in temperature until all of the water has been changed from a liquid to a gaseous state. Latent heat absorbed in the changing of a body from the liquid to the gaseous state is called the **latent heat of evaporation**. It will be noted that the large amount of 970 units of heat have been required to change the pound of water into a pound of steam with no increase in temperature, the final temperature of the steam being 212° F.

Whereas we have stated that water will change from a liquid to a vapor state at 212° F., this is true only as long as the pressure is that of the normal atmosphere. Any lowering of this pressure will result in evaporation at a lower temperature, and any increase in pressure will necessitate a higher temperature before vaporization takes place. Also the latent heat of evaporation requirements will be greater or less depending upon the pressure. Steam tables showing the properties of steam from almost a perfect vacuum to pressures in excess of 3200 pounds per square inch have been developed.

In discussing steam pressures the student must bear in mind that the average steam gauge shows only pressures in **excess** of the atmospheric pressure. Pressures below atmospheric pressure are generally spoken of as a partial vacuum, the perfect vacuum being equivalent to approximately 29.9 inches of mercury. The normal atmosphere then exerts a pressure of 14.7 pounds per square inch as compared to the perfect vacuum. Pressures which are measured in excess of the atmospheric pressure are referred to as gauge pressures. Pressures which measure from the basis of a perfect vacuum are referred to as absolute pressures. The following table shows an abbreviated steam table covering such pressures as exist in the general application to industrial processes.

STEAM TABLES—SATURATED				
Pressure		Temp. Degrees Fahr.	Latent Heat B.T.U.'s	Total Heat B.T.U.'s
Abs.	Gauge			
7.0		177	991	1136
14.7	0	212	970	1150
24.7	10	240	952	1160
164.7	150	366	856	1195
414.7	400	449	781	1204
1214	1200	567	505	1181
3014	3000	695	202	1025
SUPERHEATED 150° F.				
	400	599	781	1304

It will be noted that at atmospheric pressure, which is 14.7 pounds absolute or zero pounds gauge, the temperature of vaporization is 212° F., the latent heat 970 B.T.U.'s, and the total heat above 32° F. is 1150. All measurements of total heat and steam are calculated above 32° F. in order to eliminate the latent heat of fusion, as in industrial applications steam is never generated from ice. At a pressure of 400 pounds gauge it will be noted that the temperature of vaporization has increased to 449° F.

and that the latent heat has dropped from 970 to 781° F., but that the total heat has increased from 1150 to 1204 B.T.U.'s. A further increase of pressure to a point of 3000 pounds per square inch gauge pressure increases the temperature of vaporization to 695° F., has lowered the latent heat requirements to 202 B.T.U.'s per pound, and the total heat requirements have dropped from a high of 1204 B.T.U.'s per pound to 1025 B.T.U.'s per pound.

Superheater

Steam as it leaves the surface of the water from which it is generated is said to be in a saturated condition. Any additional application of heat to this water will not increase the temperature of that steam above that of the water from which it was generated. If, however, the steam be removed from contact with the water and then additional heat applied this steam will increase in temperature above that of the boiling point of the water from which it is evolved. This class of steam is said to be superheated.

In the generation of steam for industrial purposes, and especially so for steam that is used in turbines for the generation of power, the installation of superheaters is the general order because superheated steam will first have to lose its superheat before condensation can take place and thus the necessity of handling condensate from line losses and corrosion of turbine blades due to the formation of condensate is considerably reduced.

Fuels and Combustion

The chemistry of combustion as applied to the generation of steam is elementary but for a proper comprehension of the subject it seems advisable to consider briefly the general principles involved.

An **Element** is a substance which cannot be decomposed by any known method.

A **Compound** is a substance composed of two or more elements.

An **Atom** may be defined as the smallest unit of an element which may enter into, or be expelled from a *Compound*. Atoms never exist singly but in combination with one or more atoms to form a molecule.

A **Molecule** is the smallest unit of an element or compound that is capable of a separate existence. Molecules of the elementary gases as Oxygen, Nitrogen and Hydrogen are supposed to consist of two *Atoms*.

Combustion is the phenomenon resulting from a chemical combination evolving heat.

Oxygen is the sole supporter of combustion and a *combustible* therefore may be defined as a substance capable of combining with oxygen to

produce heat. The speed of combustion depends upon several conditions, such as the affinity of the combustible for oxygen, the temperature, and the effectiveness of the contact between the combustible and oxygen. This speed may vary over a wide range, from very slow, as in the case of rust formation (oxidation of iron) to the instantaneous combustion of an explosive mixture.

When all of the combustible matter has united with all of the oxygen it can unite with, then combustion is said to be complete. Carbon and hydrogen are by far the most important combustible elements in the fuels used for domestic and industrial purposes.

As we find in nature the combustible matter for the generation of heat, so from the same source we obtain oxygen from the air to support combustion.

Air is composed of oxygen and nitrogen with small amounts of carbon dioxide, water vapor, rare gases, etc., not chemically combined but as a mechanical mixture. For engineering purposes the small quantities of gases other than oxygen and nitrogen are included in the nitrogen and on this basis the following is the generally accepted analysis.

AIR

	By Volume Per cent	By Weight Per cent
Oxygen.....	20.91	23.15
Nitrogen.....	79.09	76.85

The oxygen with its strong affinity for the combustible constituents of the fuel, under the proper conditions of temperature, separates itself from its mechanical union with nitrogen and enters into chemical combination with the available combustible.

The nitrogen serves no purpose but is a source of direct loss as it carries off some of the heat it has absorbed when leaving the furnace.

The following table shows the chemical reactions of combustion and the resultant heat values.

Combustible Substance	Reaction	Heat Value Per Pound combust- ible in B.T.U.'s
Carbon to CO (carbon monoxide).....	$2C + O_2 = 2CO$	4,380
Carbon to CO ₂ (carbon dioxide).....	$2C + 2O_2 = 2CO_2$	14,540
CO to CO ₂	$2CO + O_2 = 2CO_2$	10,160
Sulphur to SO ₂ (sulphur dioxide).....	$S + O_2 = SO_2$	4,050
Sulphur to SO ₃ (sulphur trioxide).....	$2S + 3O_2 = 2SO_3$	5,940
Hydrogen to H ₂ O (water).....	$2H_2 + O_2 = 2H_2O$	62,000

It is important to note that carbon and sulphur may each enter into combination with oxygen to form two compounds.

Industrial Applications of the Burning of Fuels

In the burning of fuels as applied to the generation of steam the following fuels with their heat values are most generally used:

Coal.....	9,000 — 14,000	B.T.U.'s per pound
Gas.....	1,000 — 1,100	" per cu. ft.
Fuel Oil.....	17,000 — 21,000	" per pound
Wood.....	8,000 — 9,000	" per pound

The wide variation in the characteristics of these fuels require differences in furnace design for their efficient combustion. The excess air that is supplied for combustion may be manually or automatically controlled. In determining the percentage of excess air use is made of different types of CO₂ analyzers by means of which the flue gases leaving the boiler may be analyzed then indicated and recorded. These recorders may operate on the (A) chemical absorption principle, (B) electrical conductivity principle, and (C) the density principle.

The efficiency of a boiler in the generation of steam is the ratio of the heat in the fuel burned to the heat in the steam generated. With the development of higher steam pressures and, as we have pointed out before, the higher corresponding temperatures of the water within the boiler it becomes more necessary to add additional heat absorbing surfaces to supplement that of the boiler in order to reduce the losses of the high temperature gases leaving the boiler. Economizers which are used for preliminary heating of the water before it enters the boiler and air pre-heaters which are used for heating the air supply for combustion are two means of utilizing a large percentage of this heat which is rejected from the boiler. Overall efficiencies in excess of 90 percent have been obtained with the installations of a combined boiler, economizer and air pre-heater.

Industries in the Pacific Northwest to a large extent utilize hog fuel for the generation of steam. This fuel is hogged wood refuse largely from the lumber industry. Hog fuel is purchased on a unit basis of 200 cubic feet per unit. The weight per cubic foot of this class of fuel even on a dry basis will vary over a wide range depending upon the percentage of fine and coarse material, and as the heat value is dependent upon the weight of the fuel available, heat per unit will also vary accordingly. The moisture content of this fuel will usually range from 45 to 55 percent and evaporation per unit from an average grade of fuel will be approximately 11,000 pounds of steam per unit.

Types of Boilers and Furnaces

The earliest type of tubular boilers were designed so that the products of combustion passed through the tubes in the shell of the boiler and the water surrounded the tubes. This was called a fire tube boiler but at the present time practically all boilers are of the water tube type in which the water of the boiler circulates through the tubes and the heat of the gases of combustion surrounds the tubes. Fig. 131 shows a vertical cross-section through a three-drum bent tube type of water tube boiler. As will be noted this boiler is installed over a furnace with an extended flat grate Dutch oven designed specifically for the burning of hog fuel. In this type of boiler feed water enters the rear top drum flowing down the vertical tubes in the back bank to the bottom drum and circulates upwards through the incline tubes to the top front drum and then partially through the cross circulating tubes back to the rear drum.

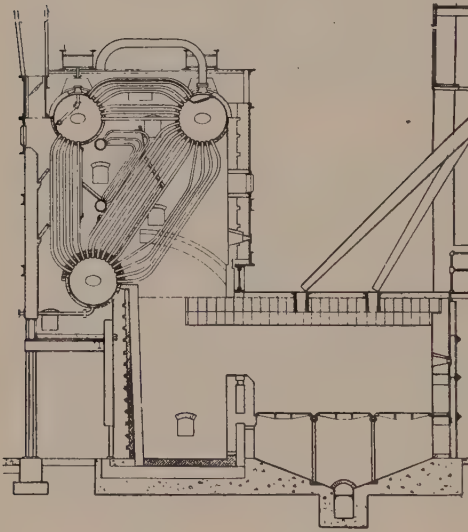


Fig. 131
Three Drum
Bent Tube Boiler

The hot gases of combustion flow upwards from the furnace passing through the front inclined bank over the top of the baffle and down the second inclined bank and superheater then upwards through the vertical third bank of tubes and out through the damper and into the smoke stack. Steam is taken from a boiler of this type from the top front drum and in this specific case then passes through a superheater located between the second and third bank of tubes and from this point is discharged directly into the steam system.

Fig. 132 shows an entirely different type of furnace although the boiler is somewhat similar to the one in Fig. 131. This is a four-drum bent tube type of boiler installed over a water wall furnace designed for the burning of pulverized coal. The pulverized coal is sprayed through the burners located in the front wall, directly into the combustion chambers. This combustion chamber is surrounded by water tubes which form a part of the boiler itself operating under the same pressure as the boiler and receiving the water as part of the boiler circulating system. It will be noted that the superheater is located between the first and second pass of tubes and that, following the boiler, is installed a large economizer section to recover part of heat remaining in the gases after they have left the boiler proper.

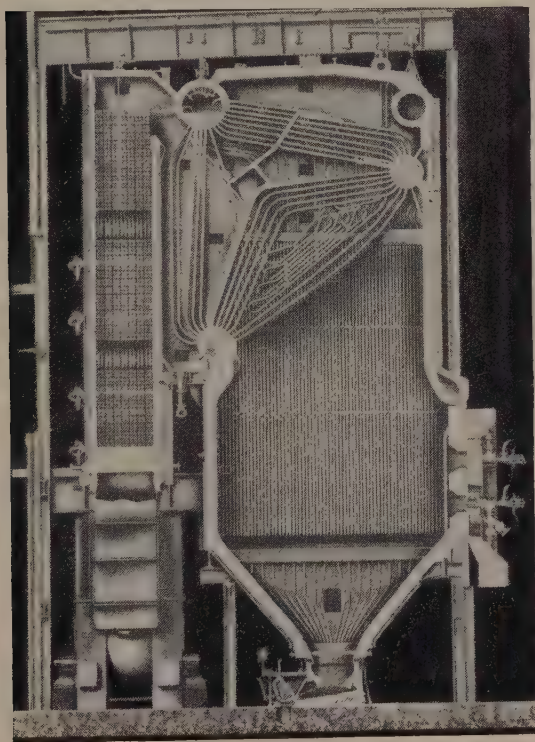


Fig. 132
Four Drum
Bent Tube Boiler

The use of water wall furnace construction is generally practiced today since, with the high temperatures from excessive rates of combustion, this type of construction has considerably reduced the cost of maintaining furnaces as compared to the refractory type of furnace.

In the earlier days of boiler and furnace design using a simple boiler only, the draft loss through such an arrangement was so low that a smoke

stack was generally all that was required to supply the necessary draft. With present day higher rates of combustion and also the necessity of supplementary equipment to the boiler as economizers and air pre-heaters, the draft loss through such an arrangement is so great that mechanical draft must necessarily be used. Forced draft fans are used to supply air to the furnaces and must overcome the resistance of the fuel bed. Furnace pressures in the combustion chamber are generally maintained at atmospheric pressure and therefore induced draft fans are necessary in order to pull the gases of combustion through the highly resistant gas passages of the boiler economizer and air pre-heater. The capacity of a boiler is generally expressed in terms of thousands of pounds of steam per hour and during the past few years boilers have been designed with capacities as high as a million pounds per hour.

Steam Engines

The steam engine is a displacement machine in which work is done by pressure acting upon a moving piston.

Engines may be classified in regard to the expansion of steam in which, with the simple engine, the steam is completely expanded in one cylinder; in compound, triple or quadruple expansion engines the steam is partially expanded first in the high-pressure cylinder and then expansion is completed in the lower pressure cylinders.

Engines are also classified by the type of valve mechanisms, as slide valve, Corliss valve, Poppet, etc. With a slide valve type of double-acting engine the admission of steam to both ends of the cylinder and the exhaust of steam from both ends of the cylinder is controlled by one valve of the slide type and generally shaped like a D in cross section. With the Corliss and Poppet valve type of engines, generally called four valve engines, individual valves are employed for the control of both the admission and exhaust from each end of the cylinder. The Corliss valve is a cylindrical type of valve and operates in a rocking motion from a wrist plate mounted on the side of the cylinder and driven by eccentric rods from the main shaft. The Poppet valve is similar in design to the Poppet valve of the automobile engine and is generally operated by eccentrics from a lay shaft which is in turn driven through a gear arrangement from the main crank shaft.

Among the disadvantages of a steam engine are (A) the excess condensation in the cylinders, (B) variable torque, especially in single cylinder engines, (C) cyclical speed variations demanding flywheels, (D) piston friction and leakage, and (E) large foundations. While many applications of the steam engine remain in use today, especially in paper machine drives, in general this equipment is being superseded by the steam turbine.

Steam Turbines

The steam turbine is a form of heat engine in which two distinct changes of energy take place: (1) the potential energy of the steam in the steam chest is first converted to kinetic energy by the expansion through a nozzle from which it issues as a jet; (2) a portion of this type of kinetic energy is converted into mechanical energy by (a) directing the jet at a proper angle against curved blades mounted on a rotor. This is called an *impulse* type of turbine, or (b) by the reaction of the jet itself if the expanding channel of the nozzle can rotate. This is called a *reaction* type of turbine.

The student may possibly be able to visualize the difference between an impulse and reaction type of turbine if he were to consider that if a jet of water were allowed to impinge upon a paddle wheel as often occurs in the simple water wheel installations, then this is comparable to an impulse turbine. On the other hand, if we picture a type of whirling lawn sprinkler in which the reaction of the jet of water as it leaves the sprinkler nozzles causes the nozzle arrangement to rotate, this is similar to the reaction type of turbine. Quite often turbines are designed which utilize both the impulse and reaction principles.

Where the steam is expanded completely in a single nozzle or wheel, then this is called a single stage turbine but where only partial expansion takes place in one set of nozzles or wheel, to be followed by further expansion through succeeding nozzles or wheels, then these are called multi-stage turbines.

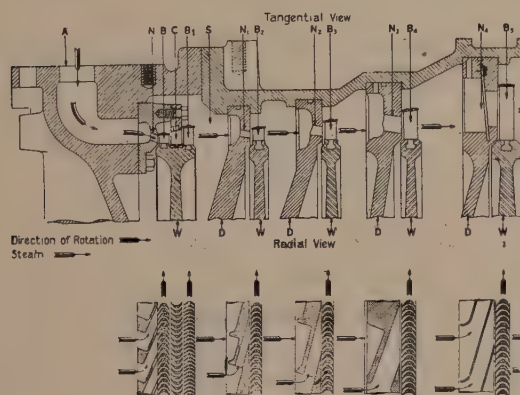


Fig. 133
Cross Section
of a 5-Stage Turbine

Fig. 133 shows a cross-section through a multi-stage turbine having five stages, the first stage of which has two sets of moving blades with a stationary set of re-entry blades located between them. It will be noted that the steam enters from the steam chest through the first stage nozzle,

expanding here and picking up its velocity and impinging upon the first row of moving blades. Upon leaving same the direction of the steam is changed by the re-entry blades from where it then impinges upon the second row of blades. Expanding through the second stage nozzle the velocity is again picked up and the steam is impinged against the second row of moving blades and so on through the third, fourth and fifth stages. Fig. 134 shows a cross-section through an extraction type of turbine. With this type of turbine, steam at high pressure is supplied to the turbine and after definite expansions have taken place and the pressure reduced to a point where it may be used for some other process, a portion of the steam may be extracted from the turbine for process use.

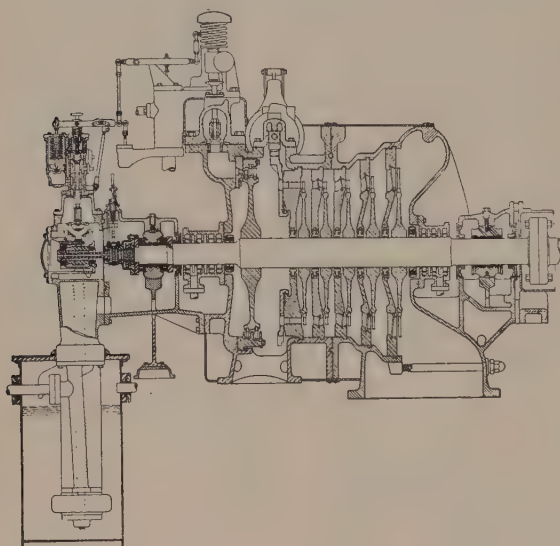


Fig. 134
Cross Section of
Extraction Turbine

CAMAS STEAM POWER PLANT

Fuel

The plant is primarily designed for the burning of fir hog fuel, which is purchased from the lumber mills on the lower Columbia River. Shipments, comprising three to five barges of 250-unit capacity each, are towed up to the plant and unloaded by an electric derrick equipped with a special type of clamshell bucket of approximately one unit (200 cu. ft. capacity).

An extensive conveyor system is installed to transfer the fuel to the steam plant and also to an outside storage area of approximately 12,000 unit capacity. The large storage area is required due to the irregular operating schedule of the lumber mills. This condition also requires that the entire plant be equipped for burning fuel oil and approximately 40,000

barrels of this fuel are kept in the storage tanks at all times. Fuel oil burning equipment is maintained in continuous operation ready to carry the entire mill load in the event of a breakdown on the hog fuel system and also to help out on the peak demands especially in the winter months when the quality of the hog fuel is below standard.

In addition to the fuel oil and purchased hog fuel, we have available from Camas wood mill operations approximately 90 units per day of hemlock wood refuse. This fuel being mostly outside wood direct from log pond storage and being further processed by wet drum barker operation, has an exceptionally high moisture content and correspondingly lower net heat value than the purchased hog fuel.

The steam production in the plant will range from 6,000,000 to 7,500,000 pounds per day (exclusive of the kraft mill Tomlinson furnace), the load being greater during the winter months and varying also with the generated electric power requirements.

During seasons when an ample supply of purchased hog fuel is available the average daily fuel consumption is as follows:

500 units purchased hog fuel.

90 units wood mill refuse.

150 barrels fuel oil.

Feed Water

A considerable amount of raw water is required for steam generation. This water carries certain amounts of calcium, magnesium and silica which, under normal conditions of evaporation, would deposit a scale formation on the water side of the boiler heating surfaces. Such scale formation would retard the rate of heat transfer, thereby reducing the efficiency of the boilers.

Water (especially condensate from steam processes) invariably carries a small percentage of free oxygen. The solubility of free oxygen in water decreases with an increase in temperature, and oxygen released from water being evaporated in a boiler, would have a strong affinity for the steel shell and tubes of the boiler, causing considerable corrosion thereof.

With such possibilities, it is necessary to minimize scale formation and corrosion, if high efficiencies and low maintenance costs are to be obtained. To attain this desirable end, a definite plan of feed water treatment is followed.

Raw water is received from Lackamas Lake, or the Columbia River, depending upon the season, and is first filtered through pressure type sand filters, after which it may be treated in the Zeolite softeners if required.

It is then pumped to the hot well to supplement the condensate returned from mill processes.

Condensate from the heating systems and motor driven paper machines is returned direct to the steam plant hot well. Condensate from the engine driven paper machines is filtered to remove traces of cylinder oil before being returned to the hot well. Condensate from the sulphite mill indirect cooking system is pumped directly to the hot well and this system is equipped with a conductivity recording and alarm system to safeguard the steam plant should one of the acid heaters leak.

Feed water is then pumped from the hot well to the deaerating heater where the temperature is raised to 274° F. and the free oxygen is removed. From the deaerating heater the water is pumped by high pressure feed pumps through the closed heater (where the temperature is raised to 330° F.) into the boilers. The Hall system of feed water treatment is employed and varying quantities of sodium metaphosphate and caustic soda are used to maintain definite alkalinities, with a desirable phosphate excess. Continuous blowdown is used to maintain safe concentrations within the boilers and sodium sulphate is added to the feed water to maintain the required sulphate ratios for the prevention of boiler steel caustic embrittlement in accordance with the A. S. M. E. Boiler Code.

Boilers, Furnaces and Auxiliaries

The No. 2 plant is equipped with two 100,000 pounds per hour capacity boilers of the four-drum Sterling type operating at 400 pounds per square inch pressure and superheating to a total temperature of 650° F.

Steam turbine driven forced and induced draft fans are used, also plate type air preheaters. The induced draft fans discharge into inverted cone vortex type cinder collectors, which form the base of individual self-supporting steel smoke stacks.

The extended furnaces for burning hog fuel are equipped with water cooled inclined grates and the hog fuel is fed from the bunkers by variable speed apron type feeders. The supplementary fuel oil burners are located in the rear wall of the furnaces.

There are two steam atomizing fuel oil burners per boiler, each burner having a capacity to generate 75,000 pounds of steam per hour. The burners are fitted with forced draft louvre type of wind boxes. Each boiler has a heating surface of 13,032 square feet, including the water walls, and a combustion chamber volume of 10,115 cubic feet.

A central control panel is equipped with recording Bailey boiler meters registering steam flow, air flow and flue gas temperatures, electrical resistance type CO₂ recorders, multipoint indicating draft gauges, push button

speed control and indicators for forced and induced draft fan speeds, recording thermometers for air temperatures in and out of the air pre-heaters, plus numerous recording and indicating pressure gauges on steam, feed water, fuel oil, etc.

There are four different steam pressure systems in constant operation. The 400-lb. system supplies steam to the forced and induced draft fan turbines, also to the two 3750 K.V.A. extraction type turbo-generators.

The 150-lb. system supplies the sulphite and kraft pulp cooking processes, also the paper machine engines.

The 60-lb. system is maintained solely for the drying system of No. 10 Yankee paper machine.

The 30-lb. system supplies all of the drying steam for the motor driven paper machines, also the mill heating and ventilating systems.

Turbo Generator Equipment

The two 3750 K.V.A. alternating current generators previously mentioned, are driven by double extraction turbines of the Curtis type operating at 3600 R.P.M.

The turbines are designed for a steam pressure of 400 pounds per square inch at the throttle and a maximum flow of 88,000 pounds of steam per hour per turbine. Steam may be extracted at 150 and 30 pounds pressure. The turbines are equipped with condensers to allow running with straight condensing, i.e., without any extraction, or any intermediate combination of extraction and condensing operation.

Each turbine has eleven stages of impulse blading, the 150-lb. extraction grid valve being located between the first and second stages, and the 30-lb. extraction grid valve between the fifth and sixth stages. The 30-lb. grid valve is designed to allow of passing a minimum of 3000 pounds steam per hour through the final five stages to the condenser. With a maximum flow of 88,000 pounds per hour to the throttle it is possible to extract in varying ratios of from 50,000 pounds per hour at 150-lb. press together with 25,000 pounds at 30-lb. pressure, to an extraction of 25,000 pounds per hour at 150-lb. and 60,000 pounds per hour at 30-lb.

The 150-lb. extraction grid valve is controlled solely by a pressure controlling device whereas the 30-lb. grid valve control pressure device is mechanically tied in with the speed governors through a three-arm mechanism. The non-return valves on the extraction lines are oil balanced and spring loaded to insure positive closing, thereby preventing the turbines overspeeding from a reverse flow.

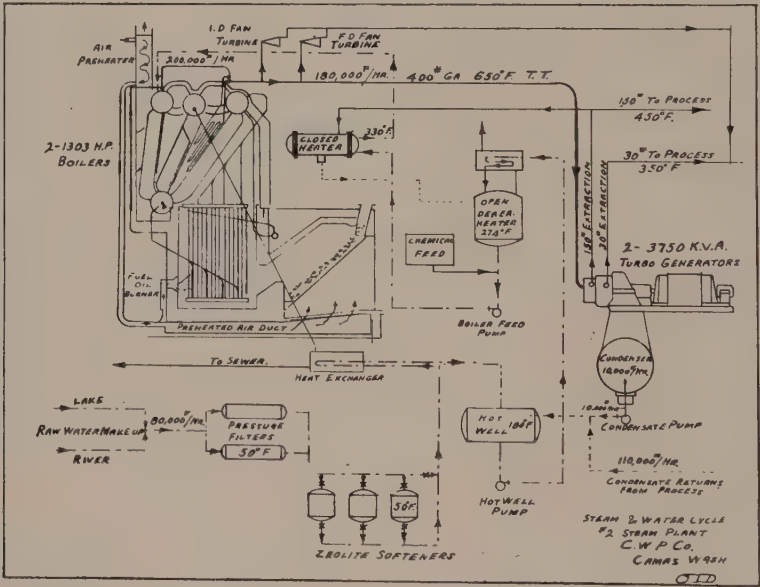
The condensers are of the surface type and of a 3-pass design. Two stage air ejectors, using 400-lb. steam on the primary and secondary

nozzles, are utilized for the evacuation of non-condensable gases. The condensers are supplied with water from the mill settled water gravity system and after passing through the condensers this water is collected in a chest and pumped back into the mill system.

The turbo-generators are 3 phase, 60 cycle, 2300 volts and have a maximum capacity of about 3800 K.W. each. They are operated in synchronism with the Northwestern Electric Company's power service to the mill.

Field excitation is supplied by a 100 K.W. 125 volt D.C. generator equipped with a dual drive using a 150 H.P. 2300 volt induction motor and a 150 H.P. 400-lb. pressure turbine. All 2300 volt switches on the generator tie in, and distribution panels are operated by remote control.

When the turbines are not in operation, the 400-lb. pressure steam is reduced to 150 and 30 pounds through two banks of reducing valves. This arrangement necessitates partial desuperheating of the lower pressure steam, and this is accomplished by two wet surface type desuperheaters operating under automatic temperature control.



Water and Steam Flow Sheet
Fig. 135

Fig. 135 showing a steam and water flow diagram of the high pressure plant will assist the student in his analysis of the plant operations.

The Low Pressure Steam Plant

There are six boilers each having 5000 sq. ft. of heating surface and one boiler of 7500 sq. ft. installed. The 7500 sq. ft. unit and four of the 5,000 sq. ft. units are equipped with flat grate extension Dutch ovens, together with forced and induced draft for the burning of hog fuel. The induced draft fans discharge into inverted cone vortex type cinder collectors. Fuel oil burning equipment is also installed for supplementary or emergency firing.

The remaining two 5000 sq. ft. boilers are equipped for burning fuel oil only, using natural draft. This entire installation is many years older than the new high pressure plant. The ratio of furnace volume to boiler heating surface is considerably less than in the more modern equipment, with the result that lower ratings are normally maintained. The average capacity with all boilers in operation is about 135,000 pounds steam per hour. These boilers operate at 150 pounds per square inch pressure and are equipped with superheaters to maintain a total temperature of 450° F. The auxiliary equipment such as steam turbine and electric driven feed pumps, also fuel oil heaters and pumps, are arranged similarly to the high pressure plant equipment.

Paper machines Nos. 4, 5 and 6 are driven by twin steam engines, and No. 7 machine is driven by a steam turbine.

Three different classes of valve mechanisms are represented as shown by the following tabulation:

Engine No.	Type of Valve Mechanism	Rated H.P.	Speed Range R.P.M.
4	Slide Valve.....	615	40— 225
5	Poppet Valve.....	810	70— 210
6	Drop Piston Valve.....	880	50— 135
Turbine No. 7		245	1100—4400

The exhaust steam from each engine is discharged directly into the respective paper machine dryer section header which supplies the drying rolls with steam for the drying of the paper. Should there be a deficiency of exhaust steam for the drying requirements, steam from the 30-lb. steam system is automatically cut in. On the other hand, should there be an excess of exhaust steam over the paper machine requirements, then this surplus is discharged into the feed water heaters at the steam plants.

In addition to the steam power plant operations, the kraft mill liquor recovery system, also the paper machine drying and vapor removal systems, offer the student many opportunities of applying the fundamental principles outlined in the early portion of this chapter.

CHAPTER XXIV

ELECTRICAL POWER

By C. F. STEVEY

Electricity is the greatest servant of man. Controlled, it lights our homes, factories and highways and turns the wheels of industry. The greater portions of the comforts of our present civilization, luxuries that we now accept as commonplace and essential, would disappear entirely but for the power of the electric current.

Paper can be made without electric power, but modern high speed mills have now become so completely electrified that a break in the flow of power through the plant will virtually cause the entire operation to stop instantaneously. Since power interruptions are costly, and because a steady flow of electric power is so vital, specially designed insulators, switchgear and other protective equipment are employed to safeguard the power supply.

Before discussing the distribution and utilization of electricity in the mill it might be helpful to those unfamiliar with the terminology to present a few brief definitions in order that the rest of the chapter may be more easily understood.

Electricity may be likened to water power. Voltage is a difference in potential like a definite head of water. This potential may exist in an electric wiring system even though no power is being drawn from it. In a similar manner, although no water may be flowing from a dam yet there is a certain potential head of water stored there. The flow of current is measured in amperes, similar to a flow of water, except that in the case of electricity, energy and not a material substance is transferred.

Water power, in flowing through a turbine, for example, is measured by the product of its pressure and rate of flow. In a like manner, the power of an electric circuit, expressed in watts, as the product of the potential and the current as follows:

$$\text{Watts} = \text{Volts} \times \text{Amperes}$$

Energy is lost in water pipes due to frictional losses, turbulence or any factor offering resistance to flow. Similarly, electrical systems offer a certain amount of resistance to the flow of current. This is expressed as ohms.

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

This means that the current, or amperes, depends on the ratio of volts to ohms. In other words, if the ohms, or resistance of a circuit increases, an exactly proportional increase in volts, or potential, is required to force the same number of amperes through.

There are two kinds of electricity generated, direct current and alternating current. In the former, the current flows continuously in one direction from positive to negative, and in the latter the current flows first in one direction, then in the other. In a 60 cycle circuit, this reversal occurs 60 times each second and may be illustrated by the following diagram.

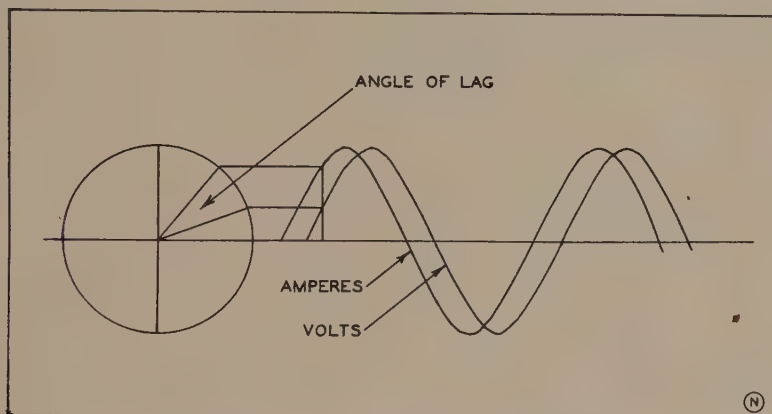


Diagram Showing Current Leading Voltage
Fig. 137

This diagram shows the voltage lagging behind the amperage. In other words, they both do not reach a maximum at the same instant, and hence, do not develop full power. The farther apart they are the less power is developed. The cosine of the angle of lag is called the "power factor." Hence, in calculating the available power in an alternating current circuit, we must take this power factor into consideration as follows:

$$\text{Watts} = \text{Volts} \times \text{Amperes} \times \text{power factor.}$$

A power factor of 0.8 is usually termed an 80 percent power factor and means that only 80 percent of the theoretical power is available. For this reason a low power factor becomes a matter of considerable concern and is one reason why we use synchronous motors as explained later.

The rate of using power is expressed as Kilowatt-hours or Kilovolt-ampere hours.

Illumination

The first commercial use of the electric current was in the form of the incandescent lamp. The lamp in those days was the carbon lamp and had

a short life with burning hours of something like 150. Today, we expect a life of 1000 burning hours out of a lamp. The date is put on the lamp when it is put in and when it burns out, reference is made to that date. If it is not 1000 hours, investigation is made to see why the full life has not been obtained. Short life, however, may be due to breakage or physical force. During the past year, our cost of light globes has only been about 60 per cent of the cost in the previous year, due to the fact that we are now using a higher voltage lamp. On Sundays, we are troubled with high voltage. This condition does shorten the life of lamps.

Good lighting always has its beneficent results, for a man works with his eyes just as much as he works with his hands. Physically, good lighting protects his eyes and guides his hands, preserves his vision and improves his skill. It is really a conservation of human material. Good lighting cuts down accidents and helps turn out a good product.

Glare has been described as light out of place. It can and does do more harm than any other part of a poorly designed lighting system. Glare causes eyestrain, which in turn results in headaches, indisposition to work, spoiled material and decreased production.

The intensity of light emitted by a source is measured in candlepower, whereas the intensity of illumination received at the work is measured in foot candles. Candlepower is the intensity of light given off by a standard candle. A foot candle is the intensity of illumination one foot away from a light source of one candlepower.

In addition, there is another and more accurate method of calculating illumination, that is, in "lumens." A lumen is the name given to a unit of light flux. It is the amount of light flux required to produce a uniform intensity of one foot candle over an area of one square foot. The efficiency of illumination accordingly may be expressed as lumens per watt.

In the paper mill proper we use about 8 foot candles. In the sulphate, sulphite, ground wood and saw mills, the illumination is approximately 5 to 6 foot candles, while in the bag factory it is 8 to 10. However, in some cases, such as typesetting, illumination may run as much as 50 foot candles.

Motors

In the Camas mill we use both alternating current and direct current motors. There are two types of A. C. motors, the induction and synchronous types. D. C. motors are divided into the shunt, series and compound types.

Induction Motors

The Squirrel Cage Induction Motor is the type mostly used for

driving pumps, conveyors and small air compressors, or drives where the starting load is comparatively light and the speed constant. Starting equipment for squirrel cage motors of 75 H.P. and less is the "across the line" starter. This means that the full voltage of the motor according to its name plate rating is applied to the terminals of the stator winding. Larger motors, of 100 H.P. and above, use a compensator that reduces the voltage when starting, and after the motor has attained full speed, full voltage is applied. The "across the line" starter and compensator protect the motor against overloading and voltage variation.

The Continuous Rated Wound Rotor Induction Motor can be operated either as a constant speed motor or at variable speed, depending upon the type of resistance and drum controller used. For variable speed operation, a resistance approximately three times that used for starting duty is necessary. This will allow the motor to be operated continuously at the full load torque without injurious heating at speeds ranging from one half to full speed. **The Intermittent Rated Wound Rotor Induction Motors** are rated on the basis of one half hour at rated load and speed with rise in temperature not exceeding 155 degrees Fahrenheit. Wound rotor induction motors are installed where heavy duty starting and variable speed drives are necessary. The resistances used with wound rotor induction motors are composed of cast iron units mounted in steel supporting frames insulated by means of mica washers and tubes. The rheostats are made in sections, which may be bolted together, thus forming a single unit.

The following is an explanation as to why an induction motor revolves. The induction motor depends for its operation on a rotating magnetic field. The stator, or primary winding, is distributed over the entire inner surface of this portion of the stator structure, which is of laminated iron and which conducts the magnetic flux. The rotor consists of a laminated iron cylinder, which has a winding of insulated wire or of copper rods or bars, imbedded in slots uniformly spaced around the periphery of the core. Where bars or rods are used, they are short-circuited at both ends by heavy copper conductors, forming a complete short-circuited rotor. In the induction motor, the magnetic field of the rotor reacts on the magnetic field of the stator by generating currents in the rotor conductors. These currents are generated due to rotor conductors being cut by the lines of force of the rotating magnetic field of the stator winding. Suppose, for example, we connect the motor terminals to a 220-volt 60-cycle current, thereby energizing the stator winding. A rotating magnetic field will be produced by this stator winding. As this magnetic field swings around within the stator structure, its lines will cut the copper bars imbedded in

the surface of the rotor. Currents will thereby be induced in the bars and these currents will generate magnetic fields around and within the rotor. Due to inter-action between the rotor and stator magnetic fields, rotation of the rotor will be produced. The effect is one of mutual induction, hence the name "induction" motor.

Synchronous Motors

There are two advantages of the synchronous motor. First, it operates at a constant speed at all loads (provided its generator runs at a constant speed). The second advantage is that it is very useful in industrial plants, having a large number of induction motors and having a low power factor, since by overexciting the field, it will produce leading currents, thereby tending to neutralize the lagging currents produced by the induction motor and thus increasing the power factor on the system. Its field is adjusted so that its power factor will be one or unity for any load and the power factor will not vary as long as the load is constant. Synchronous motors ought only to be used where the load is comparatively steady, as heavy load fluctuations cause them to produce inductive disturbances in the system. The synchronous motor uses D. C. current to excite its fields while the stator winding is connected to an A. C. supply.

The speed of a synchronous A. C. motor is determined by the number of poles built into the stator winding and the alternations of the current per minute. For 60 cycle circuit, there would be 7200 alternations per minute. Thus a 720 R.P.M. motor would have $\frac{7200}{720}$ or 10 poles. A 6-pole motor would have a synchronous speed of 1200 R.P.M., and so forth.

Nearly all 110-volt motors are single phase, the balance of the motors on 220, 550 and 2200 volt circuits are three phase.

Motor Efficiencies

The efficiency varies according to the size of the motor and the load imposed. Efficiency varies from 72 to 93 percent. This means that 72 to 93 percent of the energy or power received by the motor as electricity is delivered to the pulley as mechanical energy.

D. C. Motors

Speed Control of a Shunt Motor

An increase or decrease of voltage across the armature will respectively increase or decrease the speed of a D. C. shunt motor, the voltage across the field remaining constant. An increase or decrease of field flux will also respectively increase or decrease the speed. The simplest way to change the voltage across the armature is to have a variable resistance in series

with the armature as in a starting box. In fact, if the starting resistances are designed to carry sufficient current continuously, the handle of the starting box may be held on an intermediate point and the motor will run at a lower speed. This method has the advantage of being cheap as to equipment cost and easily applied. It has the disadvantage of wasting energy and of producing a poor speed regulation in the motor. The usual method of speed control of a shunt motor is by varying the resistance of a rheostat placed in the field circuit. By means of a variable resistance in the shunt field, we increase the resistance of the field coils. This causes a decrease of current through the coils, which, in turn, causes a decrease in the magnetization. Then fewer number of lines are cut per second by the armature coils and the counter electro-motive force is lowered. This allows more current to flow into the armature coils. This increase of current in the armature coils is much greater in proportion than the decrease in the strength of the magnetic field. Thus, the actual force or the torque of the motor is greater and the armature speeds up until a balance is again obtained.

When a slower speed is desired, some of the extra resistance is cut out and more current allowed to flow through the field coils. The armature coils then have to cut through a denser field and a higher counter electro-motive force is developed, which cuts down the current in the armature and causes it to run at a lower speed.

Series Motors

A series motor is used only where the load is always directly connected to the armature as in a fan, railway car, electric crane, etc. Series motors, unlike shunt motors, do not have a definite no-load speed. When unloaded, a series motor will continue to increase in speed until it destroys the armature by the extreme centrifugal forces set up. Very small series motors, 1/10th H.P. and under, may have friction and other losses great enough at no-load to keep the speed down to a safe limit. The racing of a larger motor may be seen by considering the behavior of the field in an unloaded series motor. The motor starts up as the current is sent into the armature and field coils, there being no opposing torque since the motor is unloaded. The speed tends to increase until the back electro-motive force equals the impressed voltage, but the ever increasing back electro-motive force decreases the current in the field and armature. As the field weakens, it requires an increased speed to set up the desired back electro-motive force. The field continues to get weak and the speed continues to increase in an effort to build up a back electro-motive force equal to the impressed voltage until the centrifugal force finally wrecks the machine.

Differential Compound Motors

Where more nearly constant speed is desired under widely varying loads than can be obtained from a shunt motor, a differential compound motor can be used. This motor has a set of series field coils bucking the shunt coils. The field strength due to these series coils, increases as the load increases, and acting against the field, due to the shunt coils, weakens the total field enough to allow a half current to flow through the armature. This current will create enough torque to overcome the extra drag on the pulley and keep the speed constant.

Cumulative Compound Motors

Sometimes series coils are added, which aid the shunt coils. The ampere turns of the series coils aid the ampere turns on the shunt coils. Such an arrangement gives the motor the advantage of the larger starting torque of a series motor without the disadvantage of the machine racing on no-load since the shunt coils maintain the field. The characteristics are somewhat like those of the series motor, the speed slowing down as the load increases as in a straight series motor. To avoid this, the series field is often short-circuited after the motor has been started. The motor then starts as a series motor, but runs as a shunt motor.

Power Distribution

The voltage on the incoming high tension line from the power company is 64,000. Through nine 2000 K.V.A. transformers, 3 banks of 3 transformers each, it is stepped down to 2300 volts. From the substation to the paper mill are three circuits.

No. 1 circuit goes to No. 4 distribution center. It consists of 12 lead covered, 3 conductor, varnished cambric insulated 800,000 circular mill cables.

Circuit No. 2 consists of 8 cables of above specifications, except 400,000 circular mills, and this circuit goes to the groundwood mill.

Circuit No. 3 consists of 2 cables of the above specifications, except 600,000 circular mill size. This goes to the bleach plant.

The circuit going to No. 4 distribution center ties in with the current coming from our generating station. This circuit coming from our generators consists of four 800,000 circular mill cables. These two circuits then take care of all paper machines and the sulphite mill. Each department or mill has its own 2200 and 550-volt sub-centers. These sub-centers have an oil circuit breaker or magnetic contactor for each motor. This gives a very flexible switching arrangement and enables us to isolate any motor.

The main distributing system in the mill is handled through cubicles as shown in Fig. 137 These are metal enclosed switchgear and metering units.

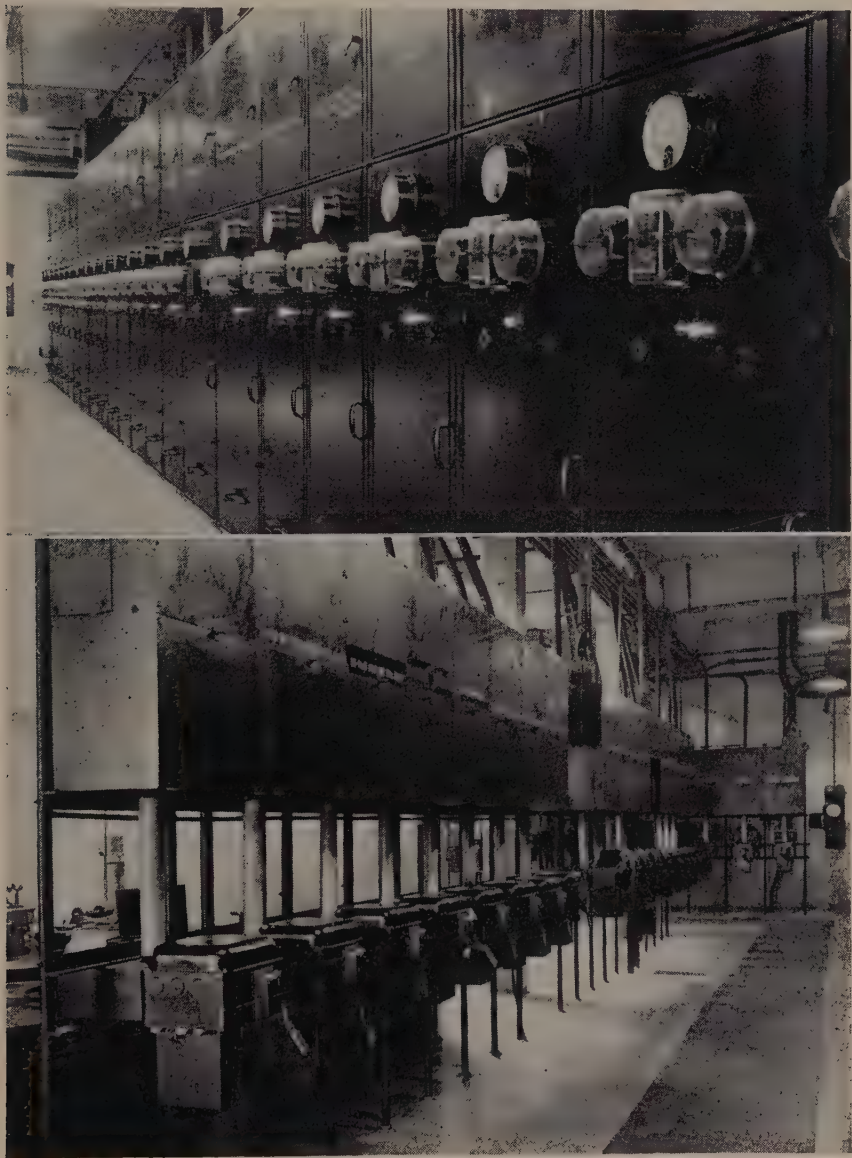


Fig. 137 The Cubicle Room

They resemble somewhat a row of steel lockers. Each one is a unit by itself.

The metal fronts are "dead" and shockproof but may be easily swung open for adjustments or repairs. Internal barriers are placed around all bus bars and bus connections. The units are free from hazard even when operated by inexperienced men.

Electrical systems throughout the mill are arranged to facilitate inspection, maintenance and extensions. Switchgear is arranged in convenient locations, places where a minimum of mechanical, electrical or fire hazard is involved. In other words, places that men in danger will run to, not run from. A number of stop stations are advantageously located on each machine as a necessary safety precaution.

The voltage used on motors of 75 H.P. and less is 550. 100 H.P. and above takes 2200 volts. We have found that the initial cost of installation, together with continuity of operation, safety to operators and protection to equipment shown on a curve drawn over a period of ten years favors very greatly the 550-volt installation in the smaller motor size.

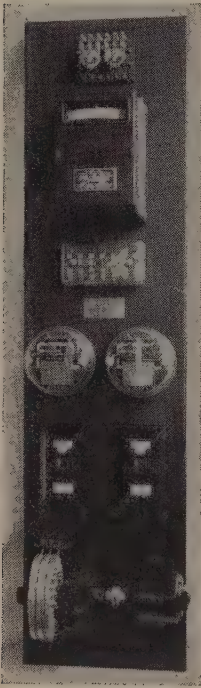


Fig. 138
Load Co-ordinator Panel

A motor should always be protected against moisture, be kept clean from grease, oil and dust, and not be housed so closely that it does not have sufficient circulation of air. Motors have an average life of 20 years, although we have had one in operation for over 40 years. At Camas we have 1,725 motors, varying from 1/30 H.P. to 1800 H.P.

Load Co-ordinator

Industrial power users generally purchase on a "block" power basis, that is, they agree to buy a certain block of power in a certain period. They pay for this power whether they use it or not, and likewise any power used in excess of the block is charged for at a much higher rate.

Since the Camas plant usage of power varies considerably, a uniform portion of our load from the block is used and the variable portion generated locally, using two steam extraction turbo-generators each rated at 3000 K.V.A. and a 750 K.V.A. non-extraction turbo-generator as a stand-by unit.

Dividing this load by manual regulation has not proven to be entirely satisfactory and a load co-ordinator was devised several years ago at the

Camas mill which automatically controls the load on the generators when the demand exceeds or drops below the block contract.

Battery Systems

In the event of a total power failure there is available a 110-volt storage battery set that can be cut in on the mill lighting system.

Electricity In the Paper Mill

The paper machine is the most important single machine in the mill. Continuous operation is essential, requiring a flexible, dependable, low maintenance drive engineered to the particular requirements of the machine under consideration. There are three types of drives used most for paper machines. They are:

- Steam drive.
- Single motor paper machine drive.
- Sectional drive.

Generator voltage control, single motor, paper machine drives have been deservedly popular for many years. Their economy, reliability and wide operating speed ranges are characteristics fitting the requirements of paper machine drives.

Improvements have been made in the control and speed regulating equipment tending towards simplification and concentration of the control so that the operator may vary the speed of the machine by turning a rheostat handle and control the operations of starting and stopping the line shaft by means of push buttons. The main driving motor may be direct connected to one end of the line shaft or provided with a double shaft extension to fit into the line shaft. On small slow speed machines, it may be desirable to use a moderate speed motor driving the line shaft through a belt, chain or gear reduction unit.

In the sectional drive the motors are supplied from a common generator, the voltage of which is varied to alter the speed of the entire machine. The generator preferably is driven by a synchronous motor. There is a central control panel, generator control panel, and a control for each section motor.

Since the sheet of paper stretches in passing through the paper machine each succeeding section must run slightly faster than the preceding one. Inasmuch as the extent to which the sheet stretches is variable, a speed changer, or means of adjusting the speed (or draw) of each section from time to time independently of the others is therefore necessary.

Since the speed of a section when once set must not vary, an automatic

regulating device is provided for each section, all of which are held in synchronism by their operation in conjunction with a master regulator.

CONTROL EQUIPMENT ON No. 10 MACHINE

Main generator—	150 K.W., 250 volts
Main motor—	180 K.W., 250 volts
Exciter—	8 K.W., 230 volts
Synchronous motor—	220 H.P., 2200 volts, 3 phase 60 cycles
Pilot generator—	280 to 1400 R.P.M.
Speed range of main motor—	240 to 1200 R.P.M.
Range by armature control—	240 to 1200 R.P.M.
Voltage range of main generator—	50 to 250 R.P.M.
Speed range of pilot generator—	280 to 1400 R.P.M.

The basic problem in the design of the single motor drive was to find or develop a speed regulator that was an accurate, sensitive, but sturdy instrument to act as the main control element.

Carbon Pile Speed Regulators

The carbon pile speed regulator is essentially a voltage regulator application. The regulator controls the speed of the motor by varying the armature voltage applied to it. In order to ascertain the speed, a pilot generator is connected to the motor to be regulated. There should be no loose coupling between the pilot generator and the main motor. (The regulator then operates for a constant voltage on the pilot generator.) The field of the pilot generator is excited from an exciter bus.

The actuating coil of the speed regulator is excited from the armature of the pilot generator, being connected in series with a motor operated rheostat. If it is desired to change the regulating speed, the resistance in series with the regulator coil is caused to vary. This in turn will cause the speed of the pilot generator and main motor to increase until the pilot generator voltage increases to such a value, as would cause the same current to flow in the regulator coil.

The regulator consists of an operating coil, dashpot solenoid operated mechanism, two sets of carbon discs and a main spring which opposes the pull of the solenoid. The pull of the solenoid is in such a direction as to release the pressure on the carbon discs which in turn increases the effective resistance. The pull of the spring which opposes the solenoid is such as to cause a decrease in resistance.

A necessary condition for stable operation of the regulator is that the pull of the solenoid must balance the pull of the spring. For a given speed

there is a certain current in the regulator coil so that there is a definite upward pull on the solenoid. This pull will then be opposed by an equal and opposite pull of the spring.

The carbon discs may or may not be connected directly in the field of the main generator. In all cases, however, their action is such as to cause an increase or decrease in the main generator voltage depending on which way the pressure on the discs changes.

Assume first a constant speed on the main motor and then assume that due to load conditions the speed decreases. This in turn means a slower speed on the pilot generator and a lower voltage impresses across the regulator coil and its series resistance. The balance in pull between the solenoid and the opposing spring is upset. The spring pressure is stronger, so that the pressure on the carbon discs is increased which action decreases the resistance of the piles. This decrease in resistance causes armature voltage of the main generator to increase until the speed of the pilot motor and the main motors are again up to that value for which the regulator is set.

The regulator is provided with dashpots which serve as a "damping" mechanism to prevent "hunting." Any sudden change of the regulator setting is transmitted through a small flexible spring to the dashpot. This means that a small change can be effected without any perceptible movement of the dashpot. A definite permanent change is then followed up by a movement of the dashpot.

Some installations are designed to cover a greater speed range than that which can be obtained by armature control alone, in which case it is necessary to use motor field weakening. The speed regulator is provided with a set of auxiliary contacts, which act in such a way as to keep the regulator from going out of control. These contacts operate a set of relays, which in turn cause a motor operated rheostat to cut in or out resistance in the main generator field, or to increase or decrease the motor field strength. As the speed adjusting rheostat is operated, the rheostat in series with the generator and motor fields is also operated. That part of the rheostat which carries the motor field circuit passes over slip rings up to the value of full armature voltage. In other words, it has no effect until the generator voltage has reached full value. From this point on, the motor field is weakened as the resistance in series with the speed regulator coil is increased, so that the net result is a constant armature voltage.

As the main motor and pilot generator come up to speed the coil of the speed regulator is energized and the regulator comes into control at the speed for which the adjusting rheostat is set.

To change speed it is only necessary to press the "Fast" or "Slow" push button. This will cause a movement of both pilot generator and main generator rheostats. The two rheostats moving at the same time will have a tendency towards causing the speed regulator to maintain practically a constant setting. Any difference in grading between the two rheostats will be compensated for by the carbon piles. If the compensation, as stated before, is beyond the range of the regulator the auxiliary contacts on the regulator will cause rheostat No. 2 to move in the right direction to make up the difference. To stop, the "Stop" button is depressed, causing all contactors and relays to be de-energized.

REFERENCE:

Volume V, Section 2—Manufacture of Pulp and Paper.

CHAPTER XXV

THE TECHNICAL DEPARTMENT

By W. R. BARBER

Evolution of the Technical Department

Technical Departments so called are relatively new adjuncts to those more progressive industrial plants which manufacture paper. To be sure the services of the chemist have been known, and the contribution of his specialized knowledge made use of as a function quite distinct from the mechanics of paper making now for several decades. From this original sparse company came those first researchers in the chemistry of cellulose as related to paper making, and more lately, in the chemistry of the cellulose and lignin of wood as that vegetable fiber material came into use. Upon their achievements the paper mill chemist of today depends for his foundation knowledge. The evolution of the paper mill chemist and his make-shift laboratory from a status of complete subordination to the empirical papermaker of the past; from a handy man to have around to make some tests if and when the papermaker wanted them; from a bare tolerance of his being retained on the payroll even during good times, to his present indispensable status and unstinted laboratory facilities has been long but persistent. He has learned he could assume a larger part in operations, and in their responsibilities, by combining with his chemistry a knowledge of engineering, that is, of applied mechanics, hydraulics, steam and electricity, so that today the technically trained man active in the operations of a pulp or paper mill is more than a chemist; he is a chemical engineer. In not a few instances, as with the Crown Zellerbach Corporation, his efforts and achievements have been rewarded even by departmental recognition, a technical service department co-equal to the other operating divisions of the mill.

Applied science is after all a thing relative to its own age. The primitive papermaker of the centuries ago somehow learned to macerate his vegetable fiber of reed or rag or straw with water laboriously by hand with mortar and pestle in order to prepare it to a state suitable for coalescence into his hand-made paper sheet. He somehow learned and applied the chemico-physical principle of "hydration," entirely as fundamental today in preparation of pulp stock for the modern paper machine. Applied science has shown how to do the operation more easily mechanically, and in a

larger way, and has explained by no means yet fully the physical and chemical basis of "hydration"; yet applied science has neither devised nor discovered a different principle for preparing vegetable fiber for making it into a paper sheet than the age-old one of associating or "beating" it with water coincident with application of mechanical energy.

We are inclined to smile at the "old days" of our own era of modern paper making when the papermaker's method of judging the bursting strength of his sheet was by a test performed with the thumb and index finger of his two hands; when his sizing test was judged by wetting a spot on the sheet momentarily with his tongue and observing the rapidity of penetration. He was doing his own "quality control" testing by what are today not approved paper testing standards to be sure, but nevertheless indicative of his sheet qualities to a degree sufficient at that time to control his paper machine and to satisfy his mill's customers. The gradual development of new uses for paper, a great many more in number and more specialized uses than he knew, pressed his successors to the need of refinements in testing their properties. Invention of instruments which do the tests mechanically, with the two advantages at the one time of providing a numerical value of the test and eliminating or at least minimizing the element of human variability in making the test have supplanted his crude methods. It has not been all gain. The sensitiveness of the old-time paper maker to the quality of his product; his accuracy of feel in knowing when his paper was right; the old-time skill of the beaterman who could tell with his hand when his stock was beaten to the proper degree of the soapy feel of hydration to an amazing degree of exactness and duplicability; some of these things have been lost and can be honestly deplored. Papermaking in the days of the hand-made papers was an art, that is, something achieved as a fine development of the senses. Even subsequent to the invention of the Fourdrinier machine it persisted as an art, gradually yielding, however, to the mechanization of the applied sciences under whose regime the technically-trained man with his books, his specialized knowledge of chemistry and physics, hydraulics and mechanics, is having a larger part, —increasingly so in the future. The graduate of the technical school is now looked upon by the empirical papermaker with a complete tolerance and with the expectation from him of a valuable assistance. The unity of purpose between the two is now regarded as an indispensable element to successful papermaking operations in production, quality, costs and even in sales promotion.

The Quality Control and Research— Functions of Technical Service

The Crown Zellerbach Corporation is outstanding among its fellow

members of the industry in its liberal recognition of the application of the sciences to pulp and paper making. The first technical department associated with papermaking on the Pacific Coast was instituted nearly thirty years ago at West Linn, Oregon, and under the supervision of Mr. F. A. Olmstead, by a company long since absorbed into the Corporation. It was a courageous, forward-looking step for those days, meager in equipment and personnel, and restricted in its opportunity of technical service. Yet growth was but a natural thing from that small beginning at West Linn to the well organized and well staffed technical departments of the several mills of the Corporation today. Note, however, that the origin of the technical department sprang from a sensing of the need for better control of product quality. The time had come when some mill agency making control of the quality of the paper product its particular assignment was in order. The customers began to make themselves audible in their desire to receive a more exact duplication of their paper purchases from one order to the next, and it became the first recognized function of the paper mill chemist, in fact, his reason for existence, to devise ways to measure paper qualities in such manner of definition and expression that the record of today's manufacture could be recorded for duplication tomorrow. It is still commonly termed "quality control."

It was but a natural result as the paper technologist was able to measure and define the characteristics of a paper sheet to guide its duplication from order to order that he began to delve into the reasons therefor, the whys and wherefores influencing duplicability. Naturally he found that the properties of a finished paper sheet could not be controlled completely from only the point where the pulp was delivered to the paper machine. He found that the pulps themselves needed to be influenced in their own characteristics in order to produce and maintain consistently the desired finished sheet properties. He found he must enter into the manufacture of those pulps, into the chemical, physical and mechanical principles governing their properties in the digester and the bleachery. More lately he is finding that he must delve into influences even farther back, into the wood itself. He has been forced to conclude that no better paper sheet can be made than is inherent in the fiber in the wood of the tree; that certain species of wood have fiber qualities characteristic of themselves which he cannot alter, but only influence as favorably as possible in their course of conversion into pulp and paper. Procedures for measuring the physical and chemical properties of pulps before they were taken to the paper machines, and of the wood and chips before they reached the digesters had to be devised in recognition that the papermaker could not be asked to duplicate yesterday's run of paper today without knowing how his pulp stock compared with yesterday's. "Quality control" testing of

pulps from the digesters and bleachery as well as of the paper from the paper machines evolved as a matter of course. The measuring and recording of the chemico-physical properties of pulps and paper, in short, the "testing" of them in a continuous routine manner as a technical service to the pulp mill and paper mill operators as an aid to them in their own responsibility of meeting the customer's demand, firstly for a paper article satisfactory for its use, secondly, for its uniformity from order to order, came to comprise the first function of technical service to a paper mill, and stands today as the first function of the Technical Department of the Camas Mill.

There is a second function of technical service of indispensable importance to the progressive paper mill, though not so immediately insistent in its performance. This is the research function. In fact, the research function has been and must always remain the forerunner of the quality control function, because the latter is the fruit of the former. Before paper testing could be done mechanically, by the use of bursting strength testers, of tear testers, of folding testers, of opacimeters, of micrometers and porosity testers, these instruments had to be perfected by painstaking research. Before the operator of the sulphite pulp digester could have the degree of delignification of the chips of his cook given him in the numerical value of "bleachability," a chemical test which necessitated research, had to be perfected. Before a new paper can be successfully put into the routine of manufacture, it must be analyzed physically, often also chemically and invariably in respect to its use. A prescription comprising its manufacturing specifications can then be prepared, defining the types and qualities of pulp to be used, the limits within which the properties, or "tests," of weight, strength, color, thickness, water resistance or sizing, gloss, opacity, stiffness or softness, and so on must fall. This is the research or development function. Paper has a myriad of present day uses which demand specific qualities to fit their use requirements. The research function has been the large force which has enabled the paper manufacturer to shape a very few sources of fiber material into an enormously wide diversification of paper sheets. Everyone is familiar with the almost complete replacement of wood boxes by paper fiber cartons, of the wrapping of bread in either highly transparent or highly opaque waxed paper wrappers. Cement, lime and clay are now packaged in paper bags. Sanitation and public health have been promoted by paper towels and paper drinking cups. Even durable wash cloths, washable pillow cases and bed sheets of a textile softness and pliability are made of paper. Even so old and plebeian a sheet as butchers' wrapping paper has had to be remodeled to meet a new condition of use arising with the advent of the retail meat dealer's refrigerated showcase. Fruit wrapping tissues specially treated chemically or otherwise for

minimizing wastage from spoilage and decay are the order of the day. The quality of common, lowly-priced newsprinting paper is being required to meet the more strict requirements of advances in the technique of printing our daily news. The demands for paper qualities to fit new uses are reaching insistently back into physical and chemical studies of wood fibers, of what goes on during their several phases of disassociation from the non-cellulose matters which hold them together in the solid wood substance. How pulping and bleaching can be carried out to incorporate, or at least to leave unimpaired, particular properties for particular paper uses, becomes an unrelenting demand upon the research chemist. Large and costly research programs are justified as a matter of necessity, if not by choice. In his need of keeping step with industrial and economic progress, in profiting by his ingenuity in meeting competition, the paper manufacturer who determined to remain in business could do nothing else but enlist the services of personnel trained in both the pure and applied sciences who in turn have rewarded him with the achievements of the research function as associated with papermaking.

The quality control function of technical service to the modern paper mill follows upon the achievements of the research function when the latter has perfected a desired result in a commercially practicable manner and carries on, to the end that the operation so instituted by the research function is kept running in the specified channel of product quality. The technical service of quality control is of the two the more immediate interest of the mill management and his operators because it has to do with current manufacture upon which filling of orders for customers and returns to the mill for defraying expenses rest. It is thus possible that the research function can be temporarily halted without immediate untoward results to mill operations. A paper mill can coast along with quality control of paper grades already established and defined as regards customers' requirements, and may thus neglect or even regard with intolerance any program of persistent research activity. A paper mill operating under such a policy would, however, be taking the same attitude as Henry Ford would have assumed if he had chosen to persist in manufacture of his model T Ford car. The research function cannot cease entirely nor be neglected if the mill is to maintain its place amid the competition of the industry.

Camas Mill Technical Department Organization

Exercise of the quality control and research functions of technical service in each of the several mills of the Crown Zellerbach Corporation is vested in a departmental unit of its own, headed by a Technical Supervisor co-equal in rank to the supervisors or superintendents of the operating units of the mill. This system is not common in the industry, but is em-

phatically progressive in its viewpoint of the relation of the applied sciences to papermaking.

While most pulp and paper mills in this day have come to the realization of the indispensability of technical service to operations, this service is more commonly exercised as responsible first to the operating superintendent, a status which tends to restrict its opportunities for fullest usefulness, instead of directly to the Mill Manager as under the Crown Zellerbach system. There is a good reason for this independency of Technical Department organization. It must be remembered that the Mill Manager is responsible to his superiors in two directions. In the one direction he must be efficient in tonnage of paper made and efficient in the cost of it. But this alone would not necessarily keep the mill operating on a profitable basis because unless the product will sell there is no money return to pay the manufacturing bills. So in the other direction he is responsible to the Sales Departments in maintaining a quality of product which will sell. The Technical Department, with its technical supervisor, being responsible directly to the Mill Manager, thus is able to act as his technical service agency in the same two directions; first, an operating technical service, and second, a sales technical service. One is just as important as the other; if anything, it is to the better interest of the mill for the Technical Department to favor the Sales Departments in cases of doubt as to quality of the product, and be on the safe side, because finally the customer is the court of last resort. Upon some occasions this rule costs the mill considerable money loss in rejection of tons of paper not up to standard specified quality. On the other hand, the rule that the Sales Departments be the first protected in matter of quality has become firmly established from long experience at Camas Mill. The operating division heads have come to be active parties in desire and effort to maintain a quality which the Sales Departments can sell. Thus the Technical Department gives the operating divisions of the Paper Mill, the Pulp Mills, the Bag Factory and Converting Plant, a service as an intermediary quality agency between them and the Sales Department.

In a mill so large as Camas, the Technical Department must itself be sectionalized in the interest of efficient accomplishment. Headquarters are in the laboratory, where also the research and development function, as well as some phases of mill technical control are performed. Quality control of the pulp and paper products is, however, necessarily localized closer to operation than would be practicable in the Laboratory: the paper testing and inspection organization is in the Paper Mill; the quality inspection of the converted products, toilet tissues and towels, is in the Converting Plant; of bags, in the Bag Factory; of groundwood, kraft, unbleached and bleached sulphite pulps, in the pulp testing station adjacent to the pulp

mills, bleach plant and the pulp drying machine; the testing of stock in its preparation for the paper machines in the beaters and jordan, in the Beater Room; the Sample Department has its separate quarters. Some other phases of quality control service to the mill are performed in the Laboratory; the preparation, issuance and supervision of the Quality Control, Manufacturing and Shipping Specifications covering each grade of paper manufactured; the clerical work of the system of stock loss and water usage measurements; examination and testing of felts and wires removed from the paper machines; the testing of raw materials purchased for mill use, such as alum, sulphur, limerock, fuel and lubricating oils; color-matching work, a technical service for the Beater Room, is done there; standard solutions for the Kraft Mill and the Sulphite Mill and Bleach Plant use are prepared and delivered. Most technical services performed from the Laboratory are such as to require graduate chemists and chemical engineers; paper and pulp testing and product quality inspection services on the other hand do not require formal technical training.

The Technical Supervisor

The Technical Supervisor in the Camas Mill is in fact a superintendent-at-large, so to speak. His is not a mill activity restricted to any one particular phase of operations. He is concerned with providing a technical service separate to each operating superintendent and a co-ordinating one for all. He must always keep in mind that his is a service department; that his assignment is not to make the product, but to serve the operators with assistance and guidance in its making. Once he fails in this realization that the only saleable product of his department is technical service, the Technical Department has lost its usefulness and lost its reason for continuance. His responsibility is to supervise the testing or quality control activity, to know and express experienced judgment whether the product as manufactured meets quality requirements which will keep a satisfied customer, at the same time, of course, exerting his own effort too toward forestalling manufacture of a product which will be unshippable. Above all, to him belongs the duty of leadership in the matter of new and improved paper products, new and improved processes of manufacture, as exercised through his research and development personnel. Competence for the job requires him to be a chemical engineer by training, and requires him furthermore to possess the capability of sound judgment which comes from a maturity of experience in pulp and paper manufacture.

The several sections of Technical Department activity are as follows:
Product Quality Supervision:

Paper Mill—paper testing and quality inspection.

Converting Plant—converted products quality inspection.

Bag Factory—bag product quality supervision.

Specifications—preparation and issuance of Quality Control, Manufacturing and Shipping specifications.

General Mill Control:

Pulp testing.

Stock preparation testing.

Mill solutions and miscellaneous tests.

Raw materials analyses.

Color matching of paper samples.

Stock and water losses.

Filter plant control.

Examination of removed machine clothing: felts and wires.

Wood quality control.

Sample Department.

Research and Development.

Product Quality Supervision

The Paper Mill testers at Camas are close to the paper as it comes off the machines. There are three paper-testing stations, placed in locations so as to cover the twelve paper machines to the best possible advantage; at the "tissue" end of the mill which handles the samples from No. 1, No. 2, No. 3, No. 9, No. 10, No. 11 and No. 12 machines; at the "wrapping" end, which tests paper from No. 4, No. 5 and No. 6 machines. "No. 8 Station" is the station near No. 8 machine and serves also No. 7 machine.

The duty of the paper testers is to test the paper according to the samples removed from the turn-up rolls off the machines, and according to the standard, approved method for each test. They record the test data on the Paper Testers Report under the proper machine and paper grade, and also indicate on the report whether the several tests show paper meeting the minimum manufacturing specification. For his reference in this respect a volume of the Quality Control Specifications covering each grade is kept at each testing station. The paper tester is not permitted to exercise judgment and decision on the shippability of the paper. Any not meeting the minimum specification he marks "hold" as not removable from the mill until inspection, review and decision by his superiors. The paper testers' job is to do the testing only and record the results.

While the paper tester's job is normally the beginner's first step in his association with paper quality control, the importance of the job must not on that account be under-estimated. To be rated as an A-1 paper tester

denotes a distinct commendation, in having applied to the job qualities of energy, alertness and self-organization in the orderly thinking essential to promote speed with accuracy, and above all, dependability. To become a first-class paper tester requires long experience, one recompense of which is the inculcation of qualities of disciplinary thinking, diligence and an automatic sense of attention to details, invaluable to a young man in any future work.

The paper tester's immediate superior is the Inspector, one each shift, who acts as the paper testing supervisor. The Inspector is a graduate paper tester of some long experience. His assignment as Inspector denotes he has demonstrated a sense of good judgment in evaluating paper quality and capability of good working relations with the papermakers. The Inspector visits each paper machine in turn and takes note of qualities of the sheets coming off the machines, such as overall formation, cleanliness, condition of rolls, and other items not apt to be readily discernible from the turn-up samples alone. He keeps the Boss Machine Tenders informed of defective paper being manufactured; exercises to a limited extent immediate decision as to shippability of "held" paper; keeps a check on the mechanical condition and accuracy of the testing instruments; supervises the paper testers in the conduct of paper testing and the character of their work, and in all ways sees that the machine operators receive satisfactory testing service. The Inspector comes into the first real exercise of his aptitude in the matter of human relationships; whether he has the talent of "getting along" with people in a cooperative manner. In the Paper Mill he is the closest element in the contact of his own department with the Paper Mill department. On him depends in a large way the measure of success or failure of the Technical Department to fulfill its mission of a satisfactory technical service to the Paper Mill.

The Converting Plant and Bag Factory are secondary paper manufacturing operations. They do not manufacture paper; they manufacture paper products from paper, that is, convert paper of particular grades into articles of shapes and sizes suitable for use. Toilet tissue paper in large rolls from the paper machines is cut and packaged for use; likewise, bag paper is fashioned into bags, towel paper into towels, napkin paper into napkins. The Inspectors assigned to quality control in the Converting Plant and Bag Factory therefore must needs learn and apply an extension of paper quality evaluation, wider in scope than known in the Paper Mill itself in order to include special reference to the converted products of toilet tissues, bags and napkins. Details of quality are scrutinized more minutely. A paper bag to be satisfactory must not only possess certain minimum strength characteristics in the paper from which it is made but it must also be well and permanently pasted, must conform to a certain

standard size, must not reach the customer in a damp or odorous condition, must not contain holes, cuts, wrinkles. In Converting Plant product inspection one determines that the toilet tissue roll is maintained at the proper size and sheet count, of the specified hardness or softness of winding, that it is correctly and attractively wrapped, that the wrapper and label are well printed, and above all, that the raw stock from which it was converted has been closely re-examined while running over the toilet tissue rewinder to make sure that defects which may have escaped notice off the paper machine are not allowed to show up prominently in the individual toilet tissue roll. In both towelling and toilet tissue the Converting Plant Inspectors exercise a considerable degree of re-examination, particularly visual and feel examination of parent stock paper sent over from the paper mill in order to insure uniformity and the specified standards of converted products quality. Final appearance of the package before being cartoned for shipment is most important. The Bag Factory and Converting Plant are operating concerns separate from the Paper Mill; they are, in fact, large customers of the Paper Mill, purchasing their paper therefrom the same as any outside customer, and thus have to be regarded as such. A goodly part of their quality control service lies in seeing that the Paper Mill supplies these two good customers with workable paper. Each plant has a quality control supervisor who is responsible directly to the Technical Supervisor and his first assistants. This supervisor in turn exercises his function of control through Converting Plant and Bag Factory Inspectors, one or more on each operating shift.

Coordinating paper and paper products quality control in the Paper Mill, the Converting Plant and the Bag Factory is first the Chief of Quality Control, whose duties are naturally to the larger extent in connection with the Paper Mill, in supervision of the Inspectors there, in the daily examination of paper samples and report, in following out discussions and instructions in respect to diversion or disposal of paper rejected from shipment, and in multitudinous ways keeping his attention on all the details of an efficiently functioning testing and paper inspection service. This Chief of Quality Control is responsible directly to the Technical Supervisor and his first assistants.

Manufacturing Specifications

All important industrial products are manufactured to certain specifications which are set up and controlled to define the limits of usability of the product and its acceptance by the trade. Paper is no exception to the necessity of manufacturing specifications. They define the required properties to insure the paper product will perform its intended use in a manner satisfactory to the customer or consumer, not on a single order but

upon repeated orders. A determined effort in establishing a specification system at Camas Mill was begun actively in 1930; now each and every one of the mill's 250 to 300 character types of paper, involving approximately 500 colors and 1500 grades when one counts also their basis weights, carry code numbered, typed manufacturing specifications, arrived at from considerations of customer experience and duly approved by signature of those concerned in the responsibility of manufacture and shipments. Any and all properties possibly measurable which have to do with defining what kind of a sheet has proved satisfactory for its intended use, are carefully prepared on the printed specification forms, reviewed and approved. The Camas Mill system of paper and paper product specifications, their preparation and promulgation is a most important service of the Technical Department, as is described in more detail in the chapter on Paper Grades and their Specifications.

General Mill Control

Pulp Testing

It is better to prevent off-quality product being made in the first place than to be forced to reject it following its manufacture. For this reason, knowing the quality of the pulp in advance of the paper machines, and having information on the beater room preparation of each batch of stock for the machines is important. These activities are performed by the pulp testing and beater testing divisions of the quality control service. The pulp testers bear the same relation to the pulp mills as the paper testers do to the paper mill. They perform tests for strength, freeness, bleachability, color, dirt count, etc., and record the data on forms provided for the purpose, which information is for the guidance of the pulp mill operators in their cooking, washing, screening and bleaching operations, and to the papermakers in knowing their pulps in advance of use. While the pulps do not carry so exactly defined specifications as do the paper grades, nevertheless they are manufactured to meet certain minimum requirements. The pulp testers, one head tester and assistant each shift, are directly supervised by a Laboratory chemist, he in turn responsible to the Technical Supervisor.

Stock Preparation or Beater Testing

The testing of stock being prepared for the paper machines, or "beater testing" activity, is one which the Camas Mill has developed in considerable detail for the purpose of providing the beater room, and in turn, the paper machine operators, with information on the pulp stock as it is furnished in the beaters and developed in its course through the jordan to the paper machine headbox, looking always toward that one object of

uniformity in quality of paper off the machines. The beater testers through consistency and freeness tests made in a standard and approved manner inform the beater room foreman when a stock is sufficiently beaten and ready to be dumped into the beater chest. Through consistency and freeness tests on the stock before and after the jordan and in the headbox of the paper machine the machine tender is kept informed of the condition of the stock going onto the paper machine wire. The machine tender's experience tells him that a certain grade of paper must meet certain of these conditions of stock uniformity from one run to another in order to make a sheet meeting its specifications. This stock preparation activity has been extended vigorously of late years to the assembling of data applying to most of Camas Mill grades. From these accumulated data it has been possible to define what particular set of operating conditions have been found most suitable for duplicating a grade of paper from run to run. The beater testers, one on each shift, bear the same technical service relation to the beater room and paper machine operators as do the paper testers, that is, to give them testing service. The beater testers are under the immediate supervision of a Laboratory chemist.

General Testing Services

Aside from these quality control activities so far mentioned there are still further technical services rendered to mill operations, centered in the Laboratory and having to do with preparation of solutions for the pulp mills, raw materials analyses, color matching and miscellaneous testing. The Kraft Mill likes to have certain daily tests to check up on their soda chemical losses which occur by way of the pulp, the washers and sewer wastes. They want daily record of data of chemical usage, recovery, pulp production, lime usage, etc. Similarly the Sulphite Mill and Bleach Plant have their needs of numerous tests on operation. These pulp mills require certain standardized solutions of acids, alkalies and iodine for the use of their operators in acid making, cooking liquor making, sludge washing, bleach cell control, etc. It is necessary for the Mill's Purchasing Department to know that incoming raw materials meet the purchase specifications, that raw materials such as alum, limerock, aniline dyestuffs, fuel oil, lubricating oils, sulphur, salt cake, lime, etc., are kept up to the specified quality the mill is paying for.

An important technical service to the beater room is "color matching," the working out of approximate aniline dyestuff formulas on a paper stock of a color not previously manufactured. This enables the beater room to know from a small scale test on the pulp stock to be used what dyes are suitable, and about how much before coloring a large batch. A miscellaneous testing service covers many other minor items.

Stock Loss Measurements

A technical service helpful to mill operations refers to stock or pulp fiber loss and water measurements. It can be readily conceived that in a mill so large as the Camas Mill with the need of so much delegated responsibility in operation of it that without careful watching on the part of the management any profits could easily be lost from the mill by way of the sewers in wastage of good papermaking pulp stock. Great strides have been made at Camas Mill in the last several years in stopping up these gaps of wastage and now a rigid circumspection and economy is enforced. In the "good old days" of papermaking it was not considered a serious matter to allow the excess of paper machine white water to run to the sewer with its rich content of good papermaking fiber unrecovered. Gradually there came the pressure of higher operating efficiency. "Savealls" and white water filters came into use. Now at Camas Mill the total amount of pulp fiber leaving the mill by way of the two main sewers, the total sewer effluent from each paper machine, the effluents from the Pulp Mills and Bleach Plant, all are kept checked up on daily and continuously. The management and operating superintendents of the Paper and Pulp Mills have a daily report which shows reliably how many pounds of pulp fiber are lost and the volume of water leaving the mill.

Filter Plant Control.

Still another, and important, service is in connection with the Filter Plant. An adequate supply of water suitable for pulp and paper making is essential. Raw water in the state of color and turbidity it happens to occur cannot be depended upon to do for manufacture of specialty papers. It must be free from silt and suspended solids, and relatively colorless, that is, not containing dissolved organic or inorganic coloring matters which would attach themselves to the pulp fibers and in turn affect their color and brightness. For bleached papers especially it must be relatively sterile. The raw water thus requires the chemical and other treatments described in another chapter. Filter plant control in the way of inspection of the quality of the water clarification, preparation of the necessary chemical testing solutions and supervision of the tests is a Technical Department service. This service, being one of a considerable responsibility, is exercised by the Technical Supervisor through one of his immediate assistants who has specialized himself along the line of water treatment and filter plant operation.

Paper Machine Clothing

Camas Mill with its twelve paper machines spends many thousands of dollars each year for felts and wires and other machine clothing. While

the expenditure is recognized as a necessary part of papermaking, and in the main, felts and wires simply wear out, yet a great deal of money can be saved or lost according to the attention given to their economy of life. A service to the Paper Mill Superintendent and his assistants in their efforts in this respect is done in the Laboratory by the testing of felts and wires which have not shown a normal "life." The tests discern wherein the unusual wear which necessitated a too early removal of the felt or wire from the paper machine occurred. Removed felts are tested by cutting test strips across their width, both lengthwise and crosswise of the weave of the felt. Tensile strengths still residual in the felt, taken on these strips and subsequently graphed, show how the felt wore across its entire width. Scrutiny of these test graphs enable the paper mill operators the better to search their machine for defective presses, rolls, suction boxes, etc., which might be causing undue wear or to judge whether a felt of a certain make and weave was the proper one for the machine. Paper machine wires are tested mainly for measurement of abrasion, its amount and kind, and by occasional chemical analysis of the metal of the wire itself, to show whether it has been made up of an improper alloy.

Wood Quality Control

Control of Camas Mill's product quality has now been extended a step farther back, into the wood itself, in effect a control of the quality of the logs brought into the woodmill to be cut into chips for the digester. The aim here is to insure uniformity at its primary source by levelling out variability in the mill's largest raw material, the wood itself. Control here prevents highs and lows in pulp quality and is reflected farther along again in minimizing variables in paper machine operation. Control is exercised by grading of the logs in rafts in advance of their being pulled into the woodmill slip, as having what percentages of No. 1, No. 2, No. 3 and No. 4 quality of logs in them. They can then be brought up in such a regulated manner that an overall average quality of wood is cut continuously. This service of quality inspection and regulation of incoming rafts is delegated to a Technical Department wood specialist.

The Sample Department

In the large manner of selling a manufactured product, it is always being sampled for showing its quality and style to both old and new customers. So with Camas Mill paper products. The Sales Departments upon whom the mill finally depends for its continued operation through disposal of the paper manufactured require a continuous service of trade samples of the entire line of papers they have to offer for sale. Trade samples involve a surprisingly large annual tonnage of printed and unprinted flat papers,

bags, toilet tissues in rolls and packs, napkins, swatches or otherwise for customer inspection. This service is given by the Sample Department which also serves the mill in current operations in selecting standard samples of each grade to be used as standards of quality. Late each day from the Sample Department files comes a sheaf of these standards in respect to color representing the grades scheduled for manufacture the next twenty-four hours. These after approval of each by an assistant to the Technical Supervisor are given to the Beater Room foreman as the standard colors to run to on the machines. Out-turn samples, folded and stamped as to grade, date and machine are sent daily to the Sales Departments and Executive Offices. The Sample Department group has its supervisor, by necessity a person of long experience in the handling, testing and judging of quality of Camas Mill papers. He is in turn responsible to the Technical Supervisor.

Research and Development

This phase of technical department work concerns delving into new things, requiring personnel of specialized training in chemistry and engineering, particularly the technology of wood, cellulose, lignin and their related subjects. This work is centered in the Laboratory and deals with problems which arise in the normal course of pulp and paper making, the answers to which are not readily ascertainable without study and experimentation separate from current operations. While the burden of the larger and more extensive problems of pulp and paper research is removed from the mill's own Laboratory by placing them with the Corporation's Central Technical Department, yet there are numerous matters of development which the mill laboratory itself must needs assume. To a large extent the research and development personnel devote their time to what may be called "trouble shooting," that is, investigation of why a certain operation is not going according to prior experience. Cases of this kind are most often reflected back to the mill through field reports upon the way the paper product is performing for the customer. Perhaps he is making use of it in a different manner than before. Often a grade of paper of a prior standardized and satisfactory quality is met by a competitor's similar grade but improved in some manner or other which causes the customer to prefer it, or at least cause him to demand the same improvement in the Camas Mill paper. Oftentimes these cases necessitate excursions into the field by a Technical Department representative, to investigate at first hand what it is the customer wants, why the former paper product is no longer satisfactory, and in all ways be better informed as to making the desired improvement in it. Instances of the development of new papers for new uses arise wherein field investigation is also desirable as first-hand aid to their development to a state of commercial manufacture.

It must be borne in mind that no mill operation can be regarded in such state of perfection that scrutiny of it for improvement in production in quality or in economy of manufacture becomes settled. There is always a little better way possible to handle the preparation of wood, the pulping of it, the bleaching of it; ways of improving strength, attractiveness in color, cleanliness from dirt specks; always a little better way of making the same products at less cost!

A few typical samples of problems of the research and development nature encountered in the past experience of Camas Mill will help to denote the important place that this phase of technical activity fulfills. The advent of the refrigerated showcase in the meat dealers' stores brought about the necessity of modification of the sizing or meat juice resistance property of butchers' papers. Meat dealers were no longer satisfied with a highly sized wrapping paper which would merely prevent soaking through of the meat juice. They now had to have one which could be used for interleaving slices of freshly-cut meats for displaying in their refrigerated showcases without the surface of the meat turning a dark, unattractive discoloration. It required patient and lengthy research to determine how this could be done and put into manufacturing practice. In the manufacture of sulphite pulps for specialty papers the trend has been toward pulps more refined in character, that is, where a greater proportion of the lignin and non-cellulose constituents is removed. These pulps, improved in color, strength and freedom from dirt specks, in turn became more difficult to size in the regular manner of using rosin size and alum. Research work in the Laboratory followed by experimental trials on the paper machine were necessary to so modify the sizing materials as to be again equally as effective. The development of waxed paper bags and box liners for dried fruits has necessitated studies of the required characteristics of the raw paper as well as the matters of their waxing; an adhesive had to be devised which would both stick together waxed paper surfaces and at the same time be a workable paste on a bag machine. For a long time apple wrapping tissue oiled almost to saturation to protect apples from a storage condition known as "apple scald" gave much difficulty in printing and handling on account of the oil causing offset and sticking of the sheets together. Here again study and experimentation brought changes in the character of the sheet which overcame the difficulty. Copper chemicals having proved a preventive to mold in pears in storage, its incorporation into a tissue sheet especially for wrapping pears was desirable. The obstacles to adding the copper chemical directly to the stock in the beaters so that the copperizing treatment could be done as the paper was being made on the machine were overcome. Papers have been made scuff-proof, relatively airproof, resistant to nitro-glycerine, made to fold and crimp correctly in bottle-capping

machines, made non-staining to the alkali of soap, and in innumerable other ways and manners made to fit particular uses. The examination of competitive paper samples sent in by the Sales Departments, complete analyses of them to determine the properties of fiber, strength, color, finish, formation, etc., and then specifying how duplication can be made from the pulps and paper machine facilities at Camas Mill, comprise an almost unending development activity of the Laboratory. In order to be efficient and sure of himself in this type of work the research and development chemist must have not only knowledge of and experience in pulp and paper technology, but must also be endowed with qualities of patience, perseverance and a lively imagination.

CHAPTER XXVI

QUALITY CONTROL AND PAPER TESTING

By T. R. MARTIN and D. L. SHINN

As the paper industry has developed with resultant competitive standards it has become increasingly necessary to be certain that the customer's requirements are being satisfactorily met and it is in this capacity that quality control serves the industry.

Inspection Organization

In determining by tests and inspection whether or not a product meets requirements as outlined by predetermined standards agreed to by both Sales Department and Manufacturing Divisions, the Technical Department is in a position to impartially judge the quality of the finished product. In the capacity of a disinterested third party it acts as agent for the Sales Department to release to the trade such products that meet shipping requirements and withhold from shipment those which do not.

The present finished product quality control organization at Camas, in addition to the Technical Supervisor and Assistant Technical Supervisor, consists of a Chief Quality Supervisor directly responsible for quality of product approved for shipment. In each of the three finished product departments, i.e., paper machines and finishing rooms, converting plant, and bag factory, the following testing and inspection staffs headed by departmental quality supervisors provide continuous 24-hour inspection.

Paper Machines and Finishing Rooms

Four Inspectors.
Twelve Paper Testers.

Bag Factory

Three Inspectors (men).
Two Assistant Inspectors (women).

Converting Plant

Three Inspectors (men).

The detailed testing and inspection service thus provided is designed to insure that any product not meeting specified standards be withheld from shipment for further examination. To this end the product not meet-

ing requirements is marked by the shift inspectors with "hold tags" provided for the purpose. The paper is later carefully examined and re-tested, after which final judgment of shipability is made.

If, upon re-examination, the product is found to conform to shipping requirements, approval for shipment is given and the product released. If, on the other hand, it is found to be below approved standards, that portion of the product thus judged defective is either diverted to a lower grade or returned to the beaters.

In addition to maintaining careful scrutiny of the quality of the sheet itself, inspectors are on the alert to discover mechanical defects, also defects in wrapping, labelling and stencilling as affecting the appearance of the finished package.

Complaints

It is the policy of the Camas Technical Department to delegate a comparatively large portion of the responsibility for quality of product to the departmental supervisors. In line with this policy, departmental supervisors are required to investigate and submit reports on complaints having to do with quality of product in their particular department.

Customer complaints are generally made to the Sales Department who in turn pass them along to the mill for investigation, and while undesirable in the sense that they express customer dissatisfaction, they do serve a useful purpose in guiding manufacture to produce paper that will fully meet customer requirements.

Each and every complaint received is thoroughly investigated to determine who and what is responsible and how to prevent a recurrence. When complete investigation has been made and the superintendent of the department involved and the technical representative are in agreement as to cause and remedy, a report is prepared by the technical representative embodying the following:

1. Full statement of the complaint and parties involved.
2. Whether or not justified and if justified, placing of responsibility.
3. Recommendations for prevention of recurrence.

Reports on complaints are signed by the superintendent of the department to which the complaint is chargeable and by the representative of the Technical Department making the investigation. It is then approved by the Technical Supervisor or Assistant Technical Supervisor.

Quality Meetings

Each day certain members of the Technical Department meet with the operating heads for a short meeting wherein test records and samples

of the previous day's production are reviewed and discussed. In this meeting specifications and requirements for special runs coming up are checked over.

Paper Tests and Instruments

The following paragraphs provide a brief description of the various paper tests and instruments used in testing paper in the Camas mill, and as a matter of convenience these tests will be divided into three groups:

Group I: Routine tests concerning the measurement of strength properties of paper. A characteristic feature of this group is that the paper sample being tested is either deformed or broken during the test.

Group II: Routine tests dealing with properties other than strength. In making the tests comprising this group, the paper samples are ordinarily unchanged.

Group III: Tests not used in routine paper testing but applied to the problems of research and development. All of the tests of the last group may, of course, be considered as belonging in either group one or group two, but for convenience in study, they will be considered separately. The three groups will be discussed in the order listed. The tests and the corresponding instruments used will be considered together.

Group I. Routine Strength Tests

(1) Mullen Test.

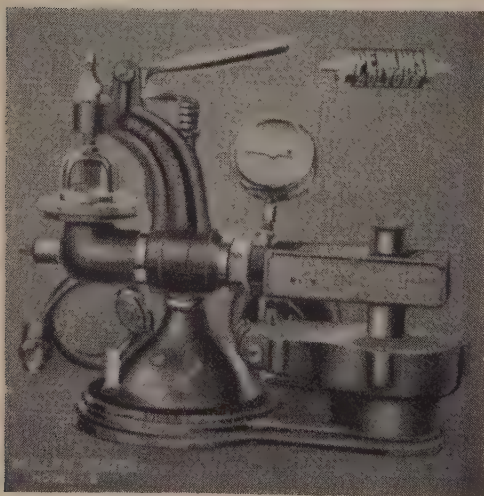


Fig. 139
Mullen Tester

The mullen test measures the resistance of paper to bursting force. In the early days this test was performed by forcing the thumb through the paper and estimating the force required. The mullen tester breaks a hole in the paper being tested by means of an expanding rubber diaphragm. A gauge records the pressure required. Essential parts of the Mullen tester are as follows:

A circular disc, with a round hole in the center exactly one square inch in area, serves as a base upon which the paper sample is clamped. Mounted directly over this disc is a metal ring which can be forced downward against the disc by means of a lever at the top of the tester. The hole in the ring is the same size as the hole in the disc and the two match exactly when pressed together. Directly under the disc a rubber diaphragm is mounted in such a way that it may be stretched upward through the hole in the disc. Below the diaphragm is a cylindrical chamber completely filled with glycerine. A liquid-tight piston or plunger seals off the other end of the chamber. By turning a knob on the tester, a motor driven mechanism is set in motion which forces the piston up into the cylindrical chamber. When the piston reaches the end of its motion it quickly returns to its original position. The glycerine displaced by the motion of the piston forces the diaphragm up through the hole in the disc and the paper clamped on the disc is thus broken. A maximum reading pressure gauge connected to the glycerine chamber records the pressure required to burst the sheet. In performing the mullen test several duplicate readings are made on the same sample. The test may be recorded as "Mullen points" or it may be calculated as "Mullen percentage." This value is obtained by dividing the Mullen points by the basis weight of the paper and multiplying by 100.

(2) Tear Test.

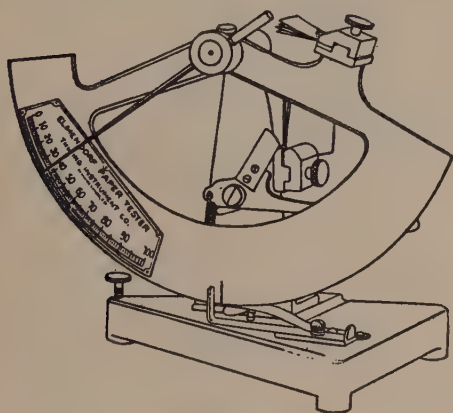


Fig. 140
Tearing Tester

The tear test measures the force required to tear a sheet of paper, after the tear has been started. The instrument used at Camas for measuring tearing strength is known as the Elmendorf tear tester. The principle of operation of this device is as follows: Several sheets of the sample to be tested, the exact number depending on the weight of the paper, are cut to size $2 \times 21\frac{1}{2}$ " and fastened securely in the screw clamps on the tester. One of these clamps is stationary, being a part of the upright frame, the other clamp is mounted directly on a pendulum built in the shape of a quadrant, or section of a circle. When clamping the paper samples, the quadrant is swung off to the left and held by a small spring clamp in such a position that the two clamps are exactly opposite one another. A small lever mounted just below the clamp is then pushed downward and released. This operation moves a knife between the clamps which makes a small cut on the bottom edge of the samples. This serves to start the tear which occurs in the final step of the test. The tear is performed by releasing the quadrant pendulum. This allows the pendulum to swing downward, moving the clamp attached to it and tearing the paper samples completely in two. During the downward swing, the pendulum gains sufficient momentum to carry it beyond its normal position of rest and it swings on up to the right, a distance which varies according to the amount of pull required in tearing the paper samples. Thus the greater the tearing strength of the paper, the more the pendulum will be retarded in its swing, and the less will be the height to which it swings after passing its lowest position. A scale is mounted on the quadrant and a pointer indicates the length of the swing. The scale reads directly in grams pull required to tear one sheet, when sixteen sheets are torn in the machine. Thus if eight sheets are torn, the scale reading must be multiplied by two. Samples are ordinarily cut so that the test is made in both machine direction and cross direction, the two tests being reported separately.

(3) Tensile and Stretch.

Tensile strength measures the force required to break a strip of paper of a given width. Stretch is simply the increase of length of the strip measured just before the strip breaks. Both of these measurements are made on the same instrument at Camas. In making tensile tests, a strip of paper $\frac{1}{2}$ " wide and 8" long is ordinarily used. The lower end of the paper is held in a screw clamp, attached to the instrument, which may be slowly and steadily lowered by a suitable mechanism. The upper end of the strip is held in a similar clamp which is attached to the hinged end of a weighted lever hanging directly downward. The bottom of this lever is fitted with a pointer which reads on a quadrant scale.

In making the test, the mechanism is set in motion which lowers the

clamp as described. This pulls downward on the strip of paper, which in turn pulls on the upper clamp swinging the weight-carrying lever to one side. The pull being applied to the paper is measured by the distance the lever moves. When the pull has increased to the point at which the paper breaks, the lever is prevented from falling back by a small ratchet. The reading of the pointer is then taken, the figure being read directly as pounds tensile strength.

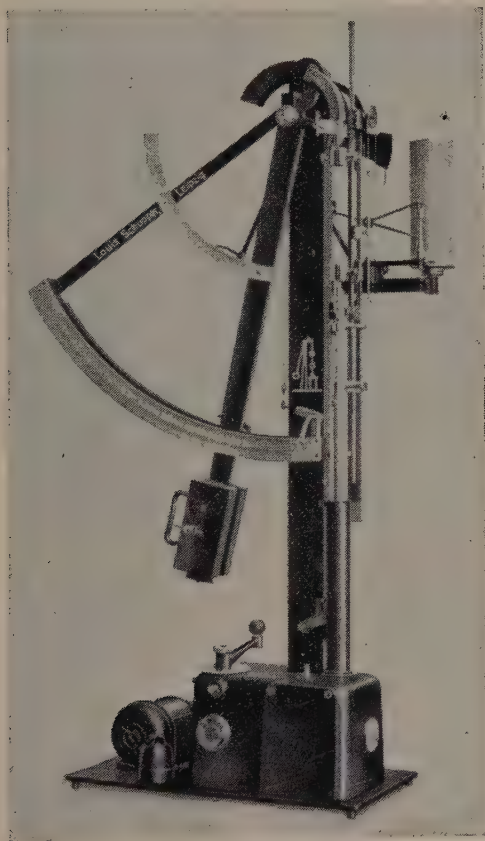


Fig. 14
Tensile Tester

A second scale mounted on the lever records the stretch of the paper up to the time of breakage. The tensile test is made in both machine and cross direction.

(4) Folding Test.

The folding test measures the number of times a sheet of paper may

be folded back and forth before breaking. This test is made at Camas on an instrument known as the Schopper folding endurance tester. A strip of the paper to be tested, $\frac{1}{2}$ " wide, is clamped horizontally between the two clamps mounted on springs. The paper strip passes between two sets of small double rollers, having a slotted metal blade between them. As

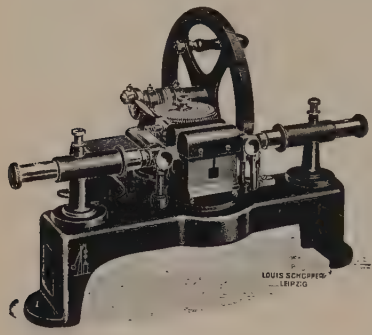


Fig. 142
Schopper Folding
Endurance Tester

the test is made, this slotted blade moves back and forth, being connected to a motor-driven shaft. Each back and forth motion folds the paper strip and a mechanical counter records the number of double folds made. When the paper finally breaks, the counting mechanism automatically stops, and the test is reported as the number of double folds withstood before the paper breaks.

Group II. Routine Tests of Properties Other than Strength

(1) Basis Weight.

At the Camas mill the basis weight of paper is expressed as the number of pounds a ream of paper would weigh, a ream consisting of 480 sheets cut to size 24 x 36 inches. In determining basis weight, it would naturally not be convenient to weigh a full ream. Weight is ordinarily determined by weighing a convenient size sample. The usual instrument for making this test is a small scale consisting of a basket or hook on which the sample may be placed, being suspended at the end of a lever connected to a pivoted hub which carries a pointer. Behind the pointer is a quadrant scale graduated in pounds basis weight. Most of these basis weight scales give directly the basis weight of a sample of paper when one sheet 24 x 36" is weighed. For determining the basis weight where only a very small sample is available, a scale is used which weighs a 4 x 4" sample of paper. Two Toledo basis weight scales are also used in Camas. These also determine basis weight by weighing one sheet 24 x 36" and are similar in operation to those used in grocery stores and meat markets.

(2) Caliper.

Caliper is simply the thickness of paper and is ordinarily expressed in inches. Two different types of instruments are used in Camas for measuring caliper. Both, however, are similar in principle. Of the two, the Schopper and Ames, only the Schopper will be considered in detail. The Schopper caliper consists of a so-called anvil, or stationary flat metal surface, upon which the paper to be measured is placed.

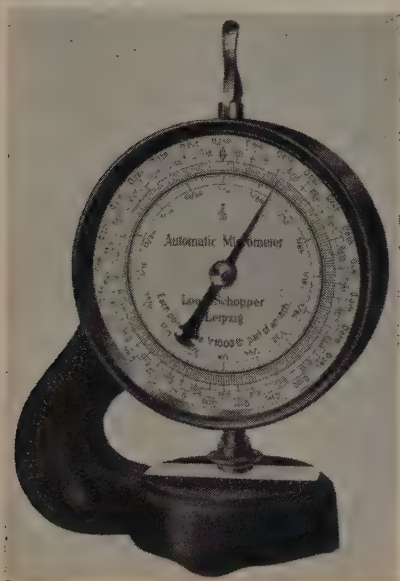


Fig. 143
Paper Micrometer

Directly over the anvil, a metal plunger is located having a flat surface exactly matching the surface of the anvil when the plunger is lowered. The plunger is connected through a system of gears to a pointer similar in appearance to the minute hand of a clock. This pointer reads on a circular scale directly in thousandths of inches. When the plunger is lowered on to the sample of paper, the pointer indicates the distance between the plunger and the anvil, or the thickness of the paper. The instrument can be read to $1/10,000$ of an inch.

(3) Densometer.

The densometer test is a measure of porosity or the ease with which air can penetrate through paper. This test is made at Camas on the Gurley densometer, which consists of a vertical cylinder mounted on a base and open at the upper end. This cylinder is half filled with mineral oil. A second cylinder, small enough so that it fits inside this large cylinder, carries at

its top end a disc clamp somewhat similar to the clamp on a Mullen tester. The only opening at this end of the cylinder is the hole in the center of

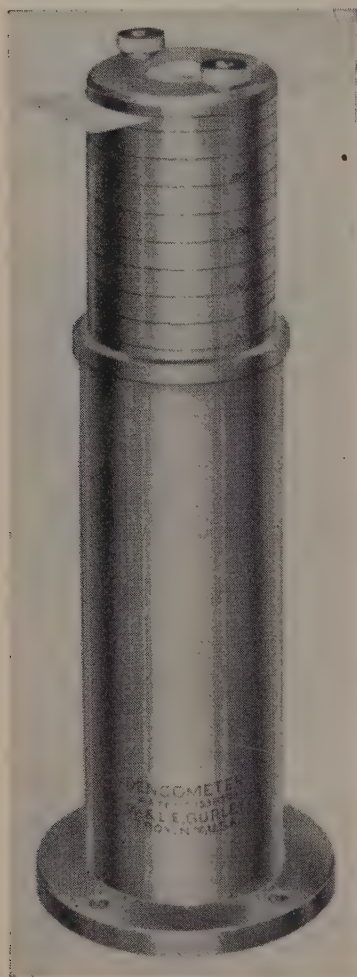


Fig. 144
Gurley Densometer

has a low gloss. Gloss is expressed as a number representing theoretically the percentage of the surface of the paper that is optically flat. Thus, a highly polished, hard surface, might have a gloss of 100. Gloss is measured by the Ingersol Glarimeter. This device consists of an electric light mounted inside a small metal container. Light escapes through an opening into a box-like pipe which is connected to the container.

the clamp, one square inch in cross sectional area. The paper to be tested is clamped so that it covers this opening or orifice. The smaller cylinder then floats on the mineral oil contained in the larger cylinder. The smaller cylinder sinks in the oil as the air contained in it is forced out through the paper. A sample of paper having high porosity will permit the air to escape rapidly and the cylinder will sink in a short time, whereas a sample having very low porosity will allow the cylinder to sink slowly. The small cylinder carries marks on its outer surface which are graduated in units corresponding to 50 cubic centimeters of air. The densometer test is the number of seconds required for the passage of 100 cubic centimeters of air through the sample. In the case of tissues, where the passage of air through the sample is comparatively rapid, we use a similar instrument but with a smaller aperture in order to obtain an accurate test.

(4) Gloss.

The gloss of paper may be roughly defined as its light reflecting power. A paper, such as glassine, having a smooth shiny surface is said to have a high gloss while a rougher sheet, such as newsprint,

The sample of paper is held against an opening at the other end of the pipe. Light strikes the paper surface and is reflected at an angle on through a tube. An eyepiece is mounted at the end of the tube, so arranged that it may be rotated, and the angle of rotation measured. In the eyepiece is mounted an optical device known as a Nicol prism. This device is able to measure a property of light known as polarization. Light when reflected from a surface is polarized to an extent determined by the

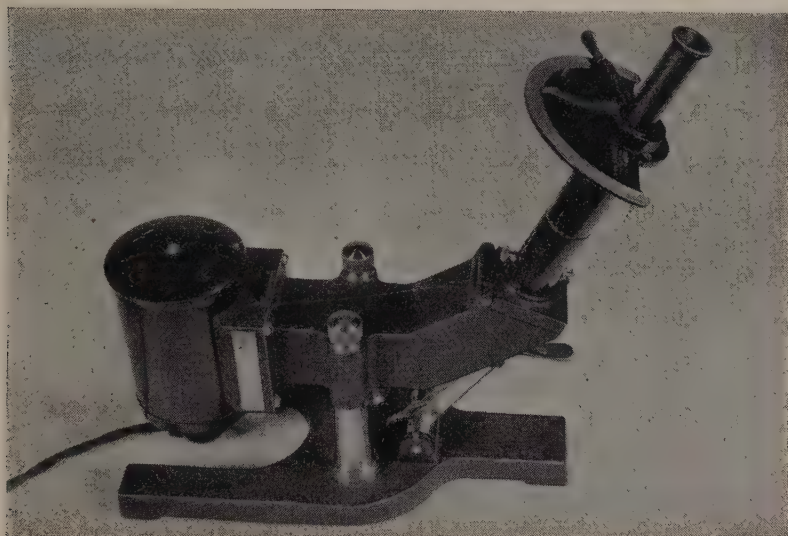


Fig. 145 Ingersoll Glarimeter

angles involved and the smoothness of the surface. Since the angle of illumination, with respect to the paper in the Glarimeter, is unchanged, only the variation in paper surface affects the polarization of the light, and thus the polarization becomes a measure of surface smoothness or gloss. For a complete explanation of polarization, the reader should consult any standard reference book on light. In measuring the gloss with the instrument the operator looks into the eyepiece. A small illuminated square is seen, divided into two equal halves. As the eyepiece is rotated, one half of the square becomes brighter or darker. The tester rotates the eyepiece until the two halves of the square appear to be equally bright. The angle of rotation is then read from a small scale attached to the eyepiece. Percentage gloss is obtained from this value by use of a table.

(5) Opacity.

The opacity of a material is a measure of its light-stopping qualities. A sheet of paper which can be readily seen through, such as glassine, is

said to be low in opacity, whereas newsprint would be considered as much more highly opaque. The opaqueness of paper is measured by an opacimeter. Several types of instruments may be used for this purpose. The instrument used at Camas is relatively simple and is probably one of the easiest types to operate. It consists of an electric light mounted in one end of a wooden box, the two halves which are separated by a partition. This partition has a hole in its center and directly behind the hole, on the opposite side from the lamp, is mounted a photo-electric cell. Whenever light strikes this cell it produces an electric current, which in turn operates a sensitive measuring instrument known as a microammeter. The amount of current produced by the cell is directly proportional to the amount of light striking it. Thus the microammeter gives an accurate measure of the amount of light striking the cell. To test a sample for opacity, the light is turned on and adjusted until the microammeter reads its full capacity, or 100. The paper is then slipped between the light and the cell. Only the light getting through the paper reaches the cell, and the microammeter now records the fraction of light that was originally striking the cell. The opacity of the paper is then taken as the difference of the two readings or, in other words, the percentage of light blocked off by the paper. The opacity of opaque waxing papers is also determined on an oiled sample in order to secure a value representing opacity of the paper after waxing.

(6) Moisture Content.

To determine the moisture content of paper, a sample is weighed on a basis weight scale. Then, after completely drying in a steam heated oven, the sample is again weighed and the weight lost during drying is calculated. The moisture content is then expressed as a percentage. This figure is obtained by dividing the loss of weight by the original weight of the sample, and multiplying the result by 100. The ovens used for this purpose at Camas are equipped with fans which circulate air through the ovens and thus rapidly carry off the water vapor produced as the samples dry. After being dried, the samples must be weighed very quickly after being removed from the oven or they will take up moisture from the air and regain some of the weight lost in the oven.

(7) Size Test.

The size test measures the resistance of a sheet of paper to water penetration. It is expressed as the number of seconds required for water to reach the top surface of a sample of paper after the paper has been dropped on the surface of water. In order to determine when penetration has occurred, a powder mixture is sprinkled on the paper. This mixture has the property of changing color the moment it becomes moist. The powders now being used at Camas consist of methyl violet and sugar, or

safranine and sugar. The methyl violet-sugar mixture turns a deep violet when moistened, and the safranine and sugar turns red. A stop watch is used to determine the time of penetration. The water must be kept at a temperature of 70° F. as the rate of penetration of water is affected by the temperature.

(8) Flotation Test.

The flotation test is very similar to the size test just described, except that it is used on papers which require a very short time for water penetration and measures the time required for complete saturation. For such absorbent grades as toilet tissue and toweling known as "bibulous" papers, where only a matter of a few seconds is necessary for penetration, this test is applied. The sample of paper is simply dropped on the surface of water and the time required to saturate the sheet is measured. In this case also the water is held at 70° F.

(9) Ink Test.

For certain types of paper, principally butcher papers, the size test is not completely satisfactory. Since these papers, in use, are subjected to contact with meat juices, the water penetrating rate is of limited value. It has been found that there is a relationship between meat juice penetration and ink penetration. The sample of paper is floated in a pan of ink for a specified length of time, and the result is reported as satisfactory or unsatisfactory at the end of that time, depending upon the amount of ink showing through.

(10) Oil Absorption.

Oil absorption measures the amount of air space or "voids" in a sheet of paper. This value is highly important in the case of papers that are to be waxed. A convenient size sample of paper, usually about 4" x 4", is accurately weighed on a 4" x 4" basis weight scale. The sample is then immersed in a bath of pure mineral oil, at a temperature of 70° F. After soaking in the oil for exactly two minutes, the sample is removed, the excess oil is scraped off by means of a metal blade, and the remaining surface oil is removed by repeated blotting with newsprint paper. The sample is again weighed on the 4" x 4" basis weight scale. The oil absorption value is then calculated as follows: The gain in weight of the paper due to the absorbed oil is divided by the original weight of the paper, and the figure thus obtained is multiplied by 100. Care must be exercised in the blotting operation since too little blotting will leave oil on the surface of the sheet and the final value will be too great, whereas too much blotting will draw oil out of the interior of the sheet and result in a low value of oil absorption.

(11) Oil Content.

Some grades made in Camas have a certain percentage of oil applied in their manufacture. Such grades as the various "Crownols" and citrus tissues fall in this group. The amount of oil applied is determined by weighing 24" x 36" samples before and after treatment. The difference is divided by the bone dry weight of the unoiled sample and the result is multiplied by 100, giving the oil content as percentage of the dry sheet. This method of determining oil content, strictly speaking, is not as accurate as actually extracting and weighing the oil, but has the advantage of being extremely rapid so that adjustments in oil content can be made immediately thereby avoiding production of any large amount of paper outside of specified oil content.

(12) Shade.

Samples from each set of paper are carefully matched with standards under special "daylight" lamps. This is done as a matter of routine. In special cases the color is measured with a color analyzer, which will be described later in this chapter.

(13) Ash Content.

Some grades of paper, chiefly opaque bread wrap and opaque liner stock, contain an added material such as titanium dioxide, to increase opacity. The amount of such mineral pigment in a sheet is determined as follows: Two and one-half grams of paper are weighed out in the form of a strip extending completely across the width of the paper machine web. This sample of paper is folded up into a small wad and is placed in a heat resisting dish known as a crucible. The crucible is then placed in an electric oven and heated to a bright red heat. This burns away all the fiber content or organic portion of the paper sample, leaving only an ash consisting almost entirely of the added pigment. This ash is then transferred to the pan of a chemical balance and is accurately weighed in milligram units (1,000 milligrams equals 1 gram). The weight of the ash in milligrams, multiplied by four, equals the percent of ash present in the sheet of paper.

In laboratory work, where ash tests are made on competitive papers, it is also customary to analyze the ash to determine its identity.

Group III. Research Laboratory Paper Tests

(1) Brightness Test.

There are two types of brightness testers in use at Camas. One, known as the Blanchard instrument, is for rough determinations of brightness and is used in routine pulp testing. The other instrument, known as the General Electric Reflection Meter, is a much more refined instrument and

is used exclusively for laboratory paper testing. This instrument makes it possible to accurately measure the brightness or brilliance of a sheet of paper, and also to measure the exact shade or color of the sheet of paper.

The principal of operation is as follows:



Fig. 146 General Electric Reflection Meter

A small electric light bulb, of the type commonly used in automobile headlights, is used as the light source. A system of lenses is placed in line with the light, extending upward from it at an angle of 45 degrees. This focuses an oblique beam of light at the center of an opening one-half inch in diameter drilled in the horizontal top of the instrument. The sample of paper to be tested is placed over this hole and is held flat by a brass weight, thus the portion of the sample covering the hole is brightly illuminated by the light striking it at an angle of 45 degrees. Directly underneath this spot there is another system of lenses which picks up the light reflected downward from the paper, and focuses it on a photo-electric cell, somewhat similar in type to the one described in connection with the opacimeter. Before reaching the cell, however, the light must pass through a diaphragm similar to the iris diaphragm in an ordinary camera. This diaphragm permits any desired amount of the passing reflecting light to be cut off. The diaphragm is controlled by a graduated dial which may be set in any desired position.

Directly behind the light bulb previously mentioned another light-sensitive electric cell is located. This cell receives light directly from the bulb and is not affected by the paper sample over the aperture. This cell is connected electrically with the other photo cell in such a way that the two oppose each other. Also, by means of a rather complicated electrical circuit, a meter is provided which indicates when the two cells are exactly balanced. When the two produce the same amount of current, they must be receiving the same amount of light. The brightness of the paper is then determined by the size of the opening which must be made in the light controlling diaphragm, in order that the two cells may exactly balance. In order to express the brightness by a figure comparable to other results, each test is made in comparison with the brilliance of a known sample. Ordinarily this known sample consists of a block of opaque glass furnished by the Institute of Paper Chemistry, the block being marked with its actual brilliance. In this way, the brightness of a sample of paper is simply compared to the brightness of the standard block. Brightness is expressed as percentage of the brightness of a block of pure magnesium oxide which is taken as 100%.

In order to test the color or shade of a sample of paper, various colored filters may be placed over the photo-electric cell measuring the reflected light. Thus, only certain colors being reflected reach this cell, and the amount of each individual color being reflected can be measured. Using a series of such colored filters, covering the whole range of visible colors, it is possible to express any particular shade as being made up of a series of brightness values, each value reporting the reflecting power for a certain color of light. Thus the color of two sheets may be compared, and it is possible to use these measured values of brightness for permanent color standards, which will never fade as is the case with color standards consisting of actual sheets of paper.

(2) Stiffness Test.

Stiffness is expressed as the amount of force required to bend a sheet of paper to a certain angle. The instrument used at the Camas laboratory for determining this property is known as the Gurley Stiffness Tester. A sample of paper of definite dimensions is placed in a small metal clamp which is fastened at the end of a lever. A metal plate rests against the free edge of the paper, and as the lever is moved, the metal blade is moved by the paper. This operates an arm carrying a weight and a pointer, the latter moving over a graduated scale. As the paper pushes the blade ahead of it the weight is swung to one side and the pointer moves across the scale. Finally a point is reached where the paper is bent by the blade sufficiently far so that the blade slips past. The value indicated by the pointer is noted

as this occurs, and this value is a measure of the stiffness of the paper. Various sized weights can be placed on the lever for testing papers having a wide range of stiffness.

(3) Resiliency.

Resiliency of paper may be defined as the "spring back" tendency. Everyone is familiar with the fact that a piece of paper folded over will tend to partially unfold when it is released. For some types of papers it is important to know just how much spring back tendency is present. The instrument used in measuring this property applied to paper, the tester, operates in a manner somewhat similar to the stiffness tester. Two identical samples of the paper to be tested are fastened with metal clips between two sets of pivoted metal blades. One of these sets of blades can be rotated by the operator, the other set being connected to an indicator carrying a weight. As the movable set of blades is rotated, the paper samples tend to be folded between these blades and the other set. As this folding process takes place, the amount of the fold is measured as the angle between the blades, and the resistance to folding is indicated by the pointer and the circular scale mounted directly underneath. When the paper has been folded to any desired angle, the motion is reversed and the paper is allowed to unfold. During the unfolding a record is kept of the force exerted by the paper at regular intervals, and the corresponding angles to which the paper is folded. This series of readings is then compared to the corresponding series of readings taken as the paper was being folded. From these figures the amount of work required to fold the paper, as well as the amount of work recovered as the paper unfolds, are both determined. The resiliency of the paper is then calculated by dividing the recovered work in unfolding, by the work done in folding the sample, multiplying the result by 100 for convenience.

(4) Sealing Strength Test.

The sealing strength test is used for determining the sealing ability of waxed papers. In wrapping loaves of bread, for example, the waxed wrap is sealed by the application of heat. If the waxed paper does not adhere strongly enough, the seal may break and the wrapper open. The sealing strength measures the ability of such a wrapper to stay sealed.

The sealing strength tester used at Camas is a modification of a device built at the Institute of Paper Chemistry for testing the strength of glue. The modified instrument measures the average pull required to separate two strips of waxed paper which have been placed together under heat. The ends of the two sealed strips are separated and each is connected to a thread. One thread is wound up on an electrically operated reel. The other

thread is connected to an indicating lever connected to a spring. The greater the pull on the thread the farther this indicating lever is moved. The lever carries at its end a marking pen which traces a curve on a paper chart rotated by the same motor which winds up the other thread. The motor is geared so that the strips are pulling apart at the rate of 21 inches per minute. The strips themselves are 4 inches long and 1 inch wide. The result of the test is obtained by planimeter measurement of the curve traced by the pen on the circular chart.

(5) Moistureproofness.

Certain types of paper, chiefly waxed papers, are used for wrapping products which must be kept moist, as in the case of bread, or dry, as in the case of crackers. For such sheets it is important to know how readily moisture is able to penetrate. In order to make this test small aluminum cups containing calcium chloride, a material having the property of absorbing water, are sealed shut by means of discs of the paper to be tested. The cups are first weighed, then placed in a cabinet in which the temperature and moisture content of the contained air are accurately regulated. After remaining in the cabinet several days the cups are removed and again weighed. Increase in weight represents the amount of water vapor penetrating through the paper covering. The area of the exposed paper sample being known, the moistureproofness can be calculated. The value of moistureproofness is expressed as the number of hours that would be required for one gram of water vapor to penetrate through 100 square inches of the paper, under the conditions of the test.

The cups used for this purpose are 1" deep and $2\frac{3}{4}$ " in diameter. The cabinet used is kept at 80° F. by means of an automatic control, and the moisture content is maintained at 70% humidity. The air is constantly circulated over the samples while the test is in progress.

(6) Fading.

The resistance of colored papers to fading when exposed to light is determined by means of a Fadeometer. In this instrument the samples are held in convenient metal clamps arranged in a circle around an arc light giving an ultra violet radiation some five times the intensity of noon sunlight. Special carbons are used to give a quality of illumination closely resembling sunlight. The clamps are arranged so that only a portion of the sample is exposed and the fading effect can accordingly be more plainly seen. For purposes of record, the degree of fading can be measured by means of the reflection tester.

The foregoing describes the principal physical tests made in evaluating and controlling the quality of paper. In addition to these there are quite

a number of special physical and chemical tests that are applied infrequently in the research laboratory and which are not intended to be covered in this book.

There is one point which is sometimes overlooked, or not given proper significance, in making paper tests, and that is the matter of sampling. Extreme care must be used to make sure that proper samples are secured. Tests are lacking in value, no matter how carefully made, if samples are not fully representative of the paper being appraised.

To get the full benefit from paper tests, it is our policy that tests shall be made as rapidly as is possible consistent with accuracy, and the results reported promptly in order that testing may be an effective means of control and not the detection of off quality paper after the damage is done.

CHAPTER XXVII

SIGNIFICANCE OF PAPER TESTS

By E. H. NUNN

The previous chapter has described the instruments and methods used in testing paper, and we come now to a consideration of the actual significance of these tests—why certain tests are made on certain grades of paper and how these tests effectively determine the ability of paper to meet the requirements of our customers.

The question might be raised as to why so many tests are made and why it is necessary to hold certain papers to such exacting requirements. Why, for example, is it necessary to measure the thickness of bread wrap to a hundred thousandth of an inch, and control its manufacture within tolerance limits of a ten thousandth? Why, again, are some sixty test determinations made on each reel of opaque bread wrap, an average of about a test per minute?

In the first place, paper is a very sensitive commodity. Often, what might appear to be a minor variation in test will produce a serious fluctuation in performance. In the second place paper is difficult to hold to uniform quality in course of manufacture. The paper industry undoubtedly has a greater multitude of independently variable factors affecting its operation than any other major chemical manufacturing industry. Only by continuous technical scrutiny in the form of inspection and control testing can it be hoped to produce paper that will uniformly and consistently meet the demands of the trade.

The best guarantee for successful performance is an adequate and properly effective testing procedure. Such a plan is the foundation for continued improvement in product quality opening up new fields of application and enabling the product to keep pace with the ever-changing picture of consumer demand.

This idea applies in practically all manufacturing industries. For example, some years ago 5000 miles was considered fair mileage for an automobile tire. Today, as a result largely of scientific control of fabric tensile strength, and abrasion, elasticity and plasticity characteristics of rubber, we expect, and get a life of 20,000 miles or more. It might be justly said that the progress and success of an industry today is based on quality control of the products which it manufactures.

So, the chief purpose of testing is to determine if the product will do the job for which it is designed. Altogether there are six principal reasons for testing paper which might be listed as follows:

1. To determine if the sheet is suitable for the purpose intended.
2. To find out if the paper is below or above competitive levels.
3. As a control of uniformity.

A tissue machine may make enough paper in ten minutes for ten thousand printed orange wrappers. Suppose then, that the strength of the paper might fall off for this short period, not only would the cost of printing, cutting, packing, shipping and selling be wasted, but these ten thousand wrappers might cause the orange packer enough trouble to make him condemn a whole shipment.

In starting up a run of bag kraft, the first set may not come up to minimum quality standards. This set may make 50,000 bags which might be sent to half a dozen different customers causing dissatisfaction and complaint wherever they went, unless the off quality paper was detected and properly condemned by testing.

So, the function of paper testing in controlling uniformity is one of its most important purposes.

4. Paper testing serves a definite function to determine if the products meet certain specific, and often unusual standards dictated by the trade or by trade agreements.

5. Testing provides a history of trends in quality and from such records it is possible to determine exactly what progress is being made in improving the value of any grade.

6. Test records yield basic information for reducing manufacturing costs. With such information changes can often be made in furnish or processing that will effect savings without adversely affecting the quality of the sheet.

Classification of Paper Characteristics

The earliest use for paper was simply as a medium on which to record thoughts or events in writing. Its requirements were simply that it have fairly good color, a moderately smooth surface and accept the ink kindly. Strength, caliper and other structural features were of secondary importance. As its uses for bags, wrapping, printing, etc., became more diversified, its requirements became more and more exacting. This gradual refinement of quality has built up a structure of use requirements that has resulted in the present day necessity for making a custom built sheet for nearly everyone.

The earliest study of customer requirements was made by direct observation of what the paper would do in the field. While this is still of the utmost importance, it has been strengthened by the ability of instruments and test methods to predict performance. Paper technicians of late years have gone a step further. They regard a sheet of paper as an engineering structure and strive to learn what modifications of this structure may produce certain valuable properties of paper, and how these modifications may be applied in practice to produce the most desirable sheet characteristics.

Possibly the earliest effort in this newer trend of thought was the work of A. S. Hammond in 1929 on the intimate structure of paper (*Paper Trade Journal*, May 14, 1929, 55). In this line of thought, the strength, surface and absorptive qualities of paper are not looked upon so much from the standpoint of interpreting the ordinary tests of paper but more from the viewpoint of how the size, arrangement, character and treatment of the component structural units, namely the fibers, produce the properties of paper. Hammond's work was followed by broader studies at the Forest Products Laboratory of Canada at Montreal and in the Forest Products Laboratory at Madison, Wisconsin, until today a great deal of valuable basic information has been assembled on the building of a sheet of paper as an engineering project.

Specifically the numerous utility features of paper may be broadly designated as structural, optical, strength and protective characteristics. Under these headings may be classified the properties of paper as follows. The methods of testing indicated are designed, so far as possible to imitate actual conditions of use. Basis weight, Mullen, moisture and caliper are the only tests made on all Camas grades. Other tests are made according to the special purposes for which the sheet is designed.

Structural Characteristics

1. Thickness or Caliper. Determined by the Ames or Schopper micrometer. An important quality of practically all papers and one easily measured. Thickness determines the diameter of toilet tissue rolls with a certain sheet count, for example, and determines whether paper towels have to be forced into a case or only partly fill it. In book papers, uniform thickness is necessary so the books will be all the same size. In printing papers, caliper must be controlled carefully so the sheet will get the same depth of impression as it goes through the press. Thickness, in a measure, controls the stiffness and hence working quality of papers to be folded or sealed on automatic machines. Other things being equal, the stiffness varies as the cube of the caliper. In other words, doubling the caliper of a sheet of paper increases its stiffness eight times.

In any case where paper is packaged by sheet count, thickness is important as customers may be suspicious of bundles of varying size, even though they contain the same number of sheets.

2. Bulk. Calculated as the bulk index, which is inches thickness per pound of basis weight, or caliper divided by weight. This is an important measurement to supplement caliper values on printing papers. For instance, if the caliper is on the high side and basis weight on the low side of specifications, the result is a bulkier sheet of different surface printing characteristics than if caliper were running on the low side and weight near the upper limits. If bulk index is held constant, however, the same type of sheet structure and surface regardless of weight variation is obtained.

Another means of determining bulk is with a pressure bulker which measures the actual thickness of a number of sheets compressed to a certain degree. This is used mostly for evaluating book papers.

3. Oil Absorption. Measured by weighing the amount of mineral oil a sheet will absorb in two minutes. This test is used mostly for waxing papers to determine their capacity to absorb wax. For example, if a 20 pound sheet has a 20% oil absorption, it will require about 4 pounds of wax to saturate it. If 8 pounds of wax be applied to such a sheet there would be 4 pounds on the surface and 4 pounds absorbed.

Since oil absorption is reduced by hydration, the oil absorption test is useful in controlling beating and jordanning, taking into consideration, of course, that oil absorption is also considerably reduced by calendering a moist sheet.

4. Water Absorption. This is determined in a similar manner by weighing the amount of water a sheet will absorb in a certain period of immersion. It is used in testing vegetable crate liners and similar sheets exposed to water in use.

5. Basis Weight. This is the primary standard for paper as it forms the basis for buying and selling. Users of printing and wrapping papers, for example, endeavor to get the maximum yardage from paper they buy and for that reason will usually specify the lowest basis weight possible consistent with strength, opacity and other requirements. Basis weight is probably checked more closely than any other quality by both manufacturer and consumer. Certain features of porosity, strength, smoothness, etc., may be essential, but are more intangible than weight variation which can be figured directly in dollars and cents. In cases of arbitration over disputed basis weights, decision should not be based on samples weighed on a 4 x 4 scale, but rather on full ream size samples weighed under standard conditions of temperature and relative humidity since the weight is affected by moisture content.

6. Moisture Content. Measured by oven test except with certain types of specially treated papers containing volatile ingredients where moisture is determined by distillation with a solvent. This method is also used for rapid moisture analysis of waxed papers which ordinarily require about 24 hours at 220° F. to remove all moisture.

Moisture has a profound effect on the working qualities of paper, particularly operation on automatic machines. Paper too low in moisture is brittle, difficult to fold and impossible to crease without splitting. Increasing the moisture content imparts added strength and pliability and excessive moisture may even make the paper too soft or "raggy" to work properly.

In addition to affecting basis weight, area and pliability, moisture variation resulting from atmospheric humidity changes affects the strength of paper very materially. Fig. 147 shows this relationship. As relative humidity increases above 40%, Mullen and tensile decreases while tearing and folding strengths increase rapidly.

In order to eliminate this effect, some paper strength tests at Camas are made in a constant humidity room maintained at 70° F. and 65% relative humidity.

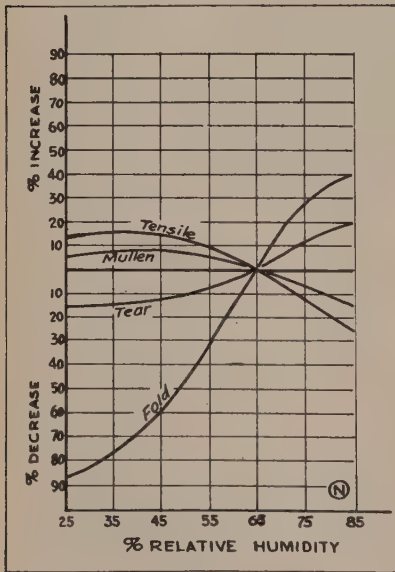


Fig. 147
Variation of Tests with Humidity

On the paper machine, moisture is an important factor in producing good gloss in calendering and in regulating caliper, oil absorption, and densometer values. In order to get good control, paper is often slightly over-dried and regulated amounts of moisture added ahead of the calenders by steaming, sweat roll or sprays. Great care must be exercised to avoid too severe over-drying which takes the "life" out of the fibers and may permanently damage their strength and pliability.

7. Curl. Very important to envelope manilas and krafts and to similar grades that must be handled in automatic machines in small sheets.

There are numerous factors in the process of manufacture that may produce curl, such as a different quality of fiber from top to bottom produced in forming the sheet on the wire, and two sided effects produced in drying and calendering. Curl may be produced or reversed at will in a sheet by moistening one side which causes the fibers on that side to expand throwing a curl towards the other side. Usually it is not necessary to measure curl since the amount of curl that will give trouble is plainly evident to the eye. However, in studying the influence of various processing factors in producing curl, the Camas research department has developed an instrument for measuring curl.

8. Loading. Measured by igniting a weighed sample and weighing the ash. Important in control of opacity and printing quality.

9. Densometer. This is a measure of the porosity or airproofness of a sheet of paper and is measured with the Gurley densometer. A high densometer test indicates a dense, well formed sheet, one that will provide a high degree of moisture proofness with a minimum amount of wax. In a surface sized sheet, either tub sized or calender sized, the densometer test is a good measure of the extent to which the surface treatment has closed up the pores of the paper. An example of this is the densometer control of casein finish gumming kraft.

Since a low degree of porosity is developed by gelatinization of fibers in beaters and jordans, the densometer test is useful in controlling hydration.

10. Oil Content. Determined by weighing ream samples before and after oiling. Control of oil content is applied mostly to fruit tissues, where it determines the value of the sheet in restricting apple scald and other degenerative fruit processes.

11. Scuff Resistance. Measured on a specially constructed scuff tester designed in the laboratories of National Paper Products Co. at Port Townsend. This test is used to control the surface resistance to scuffing on abrasion or rubbing in such products as board and tire wrap.

12. Surface Friction. In some special grades a low friction value is required as, for example, when sheets have to slide freely when fed into wrapping or lining machines. In other instances the paper must have a high surface friction as in the case of grades that are spirally wound where a high friction helps to hold the winding in place. The test is made by determining the coefficient of sliding friction on an instrument specially designed at Camas.

13. Compressibility. Determined by the Bekk Compressibility Tester. It is a measure of the ability of the sheet to take embossing or printing plate impression. Also determined by the Ball Hardness Tester

14. Stretch. Measured as "percentage stretch" on the Schopper Tensile Tester. It is associated with pliability. A sheet that is dry and brittle, in which the fiber has no "life," will show a low percentage stretch on breaking. Stretch in paper is analogous to the quality of metals known as ductility.

15. Fuzz. Determination of surface bonding strength is usually made with the Riesenfeld-Hamburger Fuzz Tester. Fuzz is an undesirable quality in printing papers making it difficult to secure sharp half-tones and causing "filling" of printing plates.

16. Formation. Measured with the Thwing Formation Tester which has a photoelectric scanning device which integrates opacity variation from point to point in the sheet.

Formation is one of the most critical of the characteristics of paper and it is only recently that proper steps have been taken by the industry to measure this very valuable feature.

One of the first things a buyer does in examining a sample of paper is to hold it up to the light and judge its formation. Many a sale has been lost for this reason and the paper never even allowed to show what it could do. A poorly formed, open-structure sheet is lacking in printing quality, strength and in moisture-proofness, water resistance and other protective features. For control purposes in the mill formation is judged by comparative rating with standards.

17. Stiffness. Determined by the Gurley Stiffness Tester. Stiffness is an advantage in some grades such as tag ledger and certain cover stocks. In most grades, however, such as bag and wrapping, toilet and towel, bread wrap, fruit wrap, twisting tissue, etc., softness or lack of stiffness is required.

18. Resiliency. Measured by the Flexometer which determines the "springback" or elasticity of the sheet. In grades that are required to take a permanent fold, such as envelope, bread wrap and carton wrappers, a low resiliency test is necessary.

19. Ink Absorption. Control of the rate and nature of ink absorption is necessary in determining the resistance of writings, and the acceptance of certain printing grades, such as newsprint and rotogravure that are printed with inks that dry by absorption.

20. Smoothness. Determined by the Bekk Smoothness Tester, which determines the "lateral surface density" or "hill and valley" nature of the surface of printing paper. This test has one disadvantage in that it is measured at light pressures compared to the relatively heavy pressure applied to the sheet in printing with stereo or electrotypes. Smoothness

is also evaluated in comparison with standards on a proofing press and by actual trial runs on rotary presses.

21. Expansion and Contraction. Certain types of pulps will show greater shrinkage in drying on the paper machine than others. Also the extent of shrinkage depends much on the degree of hydration. This feature also has a bearing on the amount of dimension change, due to moisture variation in actual use, in papers designed for closely registered multicolor printing. It is also important in some agricultural papers such as plant covers. The Cambridge Extensometer is sometimes used to measure this characteristic.

22. Rattle. Measured by the Paper Rattle Tester which is an audibility meter registering in decibels, similar to the "applause meters" used on radio programs. Certain types of paper, such as bonds, are designed to have a good rattle, others, such as special papers used for movie and radio script, are treated to prevent rattle.

Optical Characteristics

1. Gloss. Measured by the Ingersoll Glarimeter. Gloss values serve two purposes, first as a partial measure of surface printing quality, and second, to determine the attractiveness or "eye-appeal" value. Developing a good gloss in waxing is to a large extent dependent on the gloss of the base stock. The B. & L. Glossmeter has lately been devised to measure gloss by a photoelectric pickup and has advantages over the Glarimeter in being less sensitive to color and in covering a greater area of the surface.

2. Color. This is another feature of paper, like formation, that is immediately judged by buyer or consumer. For control purposes, color is matched against standard samples which are checked against recorded color measurements by the G. E. Reflection Meter.

Color is not a tangible substance but simply a sensation produced by different wave lengths on the optic nerves in the eye. The longer wave lengths produce the sensation of red, intermediate lengths orange, yellow and green, and the shorter wave lengths, blue and violet.

The extreme sensitivity of the eye in being able to distinguish small differences in color is evident when it is considered that the entire range of visibility is only about one-millionth of an inch compared to other wave forms, such as radio waves, that may measure a mile or more from crest to crest. Some people are totally color blind, that is, unable to distinguish complementary colors like red and green. It is surprising to find the number of people, however, who are partly or slightly color blind, that is, unable to judge small differences in hue in mixed colors such as blue-greens or purples.

The eye is able to accommodate itself to a wide range of illumination from starlight to sunlight nearly a billion times as strong. It is probably due to this combination of sensitivity and flexibility that our eyes often fool us. For instance, printing in green will look distinctly blueish against a yellow background, yet the same color will look yellowish against a blue background. The color nerves in the eye can become fatigued as can be demonstrated by a simple experiment. Hold a large sheet of bright green paper in a bright light and look at it steadily for five minutes. Then suddenly look at a sheet of white paper. It will appear distinctly pink since the eye has become fatigued towards green and is correspondingly more responsive to the complimentary color, red.

White light is a mixture of all wave lengths. A sheet that reflects all these wave lengths appears white and one that absorbs them all appears black. A colored paper appears colored for the reason that it absorbs part of these wave lengths, reflecting the remainder to the eye. For example, a sheet appears yellow because it absorbs the short blue waves, also the long red rays, reflecting only the intermediate yellow wave lengths. If such a sheet is able to absorb only part of the blue wave lengths, it appears green or if able to absorb only part of the red light, it would appear orange.

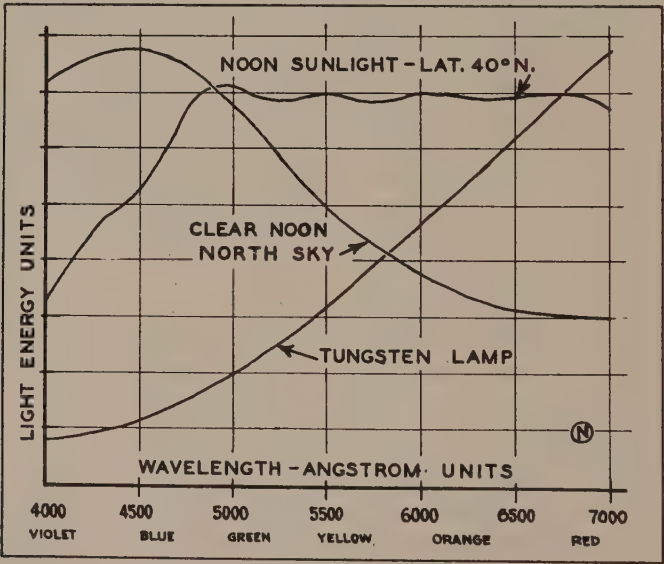


Fig. 148 Color Characteristics of Light Sources

A sheet appears red because it absorbs green light, that is, the shorter yellow and blue wave lengths. Now, if such a sheet is examined under red light it will appear white, and if examined under green light, which it

absorbs, it will appear black. For this reason the black and yellow California automobile license plates appear to have black numbers on a pure white background when illuminated by yellow sodium vapor lamps as on the Oakland Bay Bridge.

So, the color of a sheet of paper depends on the color values of the light in which it is examined. Fig. 148 shows the wide differences between ordinary means of illumination. An ordinary electric light is rich in red rays and deficient in blue. Examination of a blue-white sheet under artificial light would make it appear much duller than if viewed in north daylight which is rich in blue wave lengths.

Blue-white papers appear brighter to the eye than yellow-white sheets even though addition of the blue dye actually has a dulling effect. For this reason, the Paper Grading Committee of TAPPI decided to grade brightness of white papers according to their reflectivity in blue light, this being more in accordance with visual grading which, after all, is the final criterion since the customer, whether color blind or not, must be satisfied regardless of instrument readings.

For color grading in the mill, specially designed blue "daylight" lamps are used which have the general characteristics of north daylight but which are more constant from day to day and from season to season.

"Value" is the lightness or darkness of a color tending towards white in one direction and black in the other. For example, a red varies in "value" from a pale pink to a very dark red. "Chroma" is the strength of color. Two reds may have the same hue and value yet one may be a much stronger color than the other.

Industry is becoming more and more color conscious and many commodities, such as coffee, beer and gasoline, are required to meet color standards both for appearance and identification. The paper industry is closely identified with color trends evidenced by the attention that is being given to the influence of color in designing packages of high consumer appeal for staple commodities.

Fading tests are made on colored papers by exposing them to a special arc light. This test is used to determine the color permanence of tire wrap, colored soap wrap, certain manilas and other grades exposed to sunlight in actual use.

3. Dirt. Checked by speck count. Like color, dirt may not affect the performance of paper but is a feature readily appraised by the consumer and a dirty grade of paper usually gets no further than a purchasing agent's desk, particularly if it is supposed to be a high grade sheet.

4. Opacity. Determined by photoelectric opacimeter readings. Opacity is a necessary feature of such printing papers as newsprint, magazine, and

book that are printed on both sides. Such papers, when low in opacity, may exhibit what is known as "show-through" where printed matter shows through faintly, confusing the printing on the opposite side.

The trend in packaging of late years has been towards the extremes of transparency and opacity. An opaque white bread wrapper or carton wrapper, besides hiding the contents of the package, gives it a sanitary appearance, and provides an effective background for printed matter.

Opacity measurement is valuable to avoid costly over-pigmenting when using expensive zinc and titanium pigments.

5. Transparency. We are accustomed to think of optical systems in terms of mirrors, lenses and prisms. However, paper is an optical system in itself; it reflects, absorbs, refracts and transmits light in varying degrees. A transparent paper is one that is ordinarily thought of as transmitting a large proportion of incident light falling on it. Lately, however, it has been determined that a better measure of transparency is not only the ability to transmit light but to do so without refracting or diffusing the light rays. A waxed glassine, for example, may appear substantially as transparent as cellophane when placed in direct contact with a printed page but when held an inch or two away from the page makes it more difficult to read the printing due to its greater tendency to diffuse the light passing through it.

An instrument has recently been designed by Dr. D. B. Wicker at the Institute of Paper Chemistry for measuring parallel transmittance. This test defines the "transparency ratio" of a sheet as the ratio of parallel to total transmittance.

When light rays pass from one medium to another, as from air to cellulose, they are reflected or refracted (or bent). For this reason an ordinary sheet of paper has a relatively high opacity considering that cellulose itself is quite transparent. If, however, the fibers are crushed together to destroy most of these air-fiber interfaces, as in supercalendering, transparency is increased. If the remainder of the air spaces are filled in with a material such as wax, having a refractive index substantially equal to cellulose, transparency is further increased.

Strength Characteristics

1. Bursting Strength. The Mullen test holds a time honored position among paper tests as it has long been the basis of mutual appraisal by both producer and buyer. However, it is a serious error to judge a sheet on Mullen test alone. For example, a 20 pound glassine and a 20 pound kraft may both have 90% Mullen strength but have widely different tearing strengths and would not be at all suited for the same purposes.

Mullen strength measures the resistance of a sheet to punching through

by any solid object such as a bone, a piece of ice or the corner of a carton.

2. Tearing Strength. The Elmendorf Tear Tester measures the resistance of a sheet to tearing once an initial tear has been started. This is an important test for papers subjected to rough handling such as grades used on automatic lining and wrapping machines:

Tearing resistance is affected by fiber treatment, jordaning reducing tear by shortening the fibers. Accordingly, the tear test is useful in regulating beating and jordanning. Hydration often increases Mullen at the expense of tearing strength.

3. Tensile Strength. This is a measure of the direct pull on paper. It is important in grades subject to severe stresses such as gummed tape, bags, tire wraps, twisting tissue and fruit wraps. It is useful also in controlling the utility value of light weight printing papers subject to tension in printing presses.

4. Folding Endurance. Determined by the Schopper or M. I. T. Folding Testers These machines both register the number of double folds required to break the paper. This test is important on envelope, cover stock or other grades that are folded in converting operations. Folding endurance is affected more than any other test by moisture and must be determined under constant humidity conditions.

5. Wet Strength. Determination of Mullen strength after immersing in water is useful in determining the merits of grades that are actually exposed to moisture in use, such as vegetable wraps and liners, ice wraps and butcher liners.

6. Ply Adhesion. Measured by the Peerless Adhesion Strength Tester. Used in testing adhesion of asphalt and waxed laminated papers, gummed tape, etc.

7. Creasing Strength. The ability of a sheet to take a crease without breaking is measured by the Thwing Folding Strength Tester. It is used to supplement folding endurance on envelope, cover and similar grades.

Protective Characteristics

1. Waterproofness. There are several tests used to determine this. One is the ordinary sugar-dye size test and another is the penetrometer test where liquid is forced through the sheet under pressure. Both are used to determine the rate at which water will penetrate such papers as kraft and sulphite wrapping, bag, butchers, vegetable wraps, gumming and other grades encountering moisture in converting or use. For the bibulous type of papers where the absorption rate is comparatively rapid, the test is made either by flotation on water or measuring the rate of absorption of a drop of water. Paper towels should be absorbent but should not absorb water

so rapidly that they go to pieces before they have served their purpose.

2. Moistureproofness. Resistance to water and to water vapor are not necessarily correlated characteristics. A heavily sized or lightly waxed sheet may have a high degree of water resistance by virtue of the interfacial tension between water and rosin or wax, but may have a very low moistureproofness value.

Certain products such as biscuits, corn flakes, potato chips, sugar and dynamite lose quality if moisture is allowed to get at them. Other products such as bread, tobacco and prunes require keeping the moisture in. The moistureproofness test, as described in the preceding chapter, enables us to design a sheet for each requirement.

In waxed papers, moistureproofness depends partly on the amount of surface wax and partly on the porosity of the base paper. A glassine, for example, after waxing, has a much higher moistureproofness than a waxed sulphite of more open structure. Freedom from pinholes is a desirable quality in a waxing sheet designed for moistureproofness.

3. Odor and Flavorproofness. Airproofness and flavorproofness have no direct relation to moistureproofness. A waxed sheet, for example, may be very moistureproof yet not flavorproof if the volatile flavoring ingredient is soluble in wax. On the other hand, unwaxed glassine or plain cellophane is extremely air and flavorproof but very low in moisture protective value.

An example of a sheet specially designed for a specific purpose is the glassine manila laminated liner used for certain gelatin desserts and which combines the elements of flavor proofness and moistureproofness.

A wrapper designed to protect the flavor of footstuffs must, of course, have no predominant odor of its own, and the odor of inks used to print such papers must be held to a minimum.

4. Greaseproofness. The test is made by timing the rate of penetration of oil and is valuable in estimating the quality of paper for packaging butter, mayonnaise, potato chips, peanut butter, biscuit flours, and other products of an oily nature. Ordinary paper, parchment and waxed papers are not greaseproof but highly hydrated sheets such as greaseproof and glassine, also cellophane, are highly grease resistant. Certain types of synthetic resin treatments are now appearing on the market for making paper oil and grease proof. An example is the newly developed process for resin treatment of fiberboard in making lubricating oil cans.

5. Moldproofness. Certain types of paper have to be specially treated to prevent development of mold either in the paper itself or in the packaged products. This is accomplished by adjusting the breathing rate of the paper or by incorporation of fungicides.

6. Meat Juice Resistance. Determined by rate of transmission of writing ink which has viscosity and penetration characteristics similar to meat juices. The test is used on butcher manilas, waxed butcher liners and paper used for interleaving steaks.

7. Fruit Juice Resistance. Certain papers used for lining cartons for seeded raisins, prunes, fruits for freezing and similar products are tested for resistance to penetration of the juice of the product under consideration.

8. Thermal Insulating Value. This characteristic is necessary in ice wrap and building papers and is also a factor in containers for frozen foodstuffs.

9. Dielectric Strength. Electrical conductivity tests are applied to paper that must have a high dielectric or electrical insulating value.

<u>PAPER CHARACTERISTICS</u>	
<u>A-STRUCTURAL</u>	<u>B- OPTICAL</u>
Thickness	Gloss
Bulk	Color
Oil Absorption	Dirt
Basis Weight	Opacity
Moisture	Transparency
Curl	
Filler	<u>C- STRENGTH</u>
Densometer	Mullen
Oil Content	Tear Test
Scuff Resistance	Tensile
Surface Friction	Fold
Rattle	Wet Strength
Compressibility	Ply Adhesion
Stretch	Creasing
Fuzz	<u>D- PROTECTIVE</u>
Formation	Waterproofness
Stiffness	Moistureproofness
Resiliency	Greaseproofness
Ink Absorption	Moldproofness
Smoothness	Meat Juice Resistance
Expansion	Fruit Juice Resistance
	Thermal Insulation
	Electrical Insulation
	Tarnish Resistance
	Odor and Flavorproofness
	Alkaliproofness
	Permanence

Fig. 149

10. Tarnish Resistance. Tissues used in wrapping silverware must be free from sulphur compounds which would tarnish the metal. This test is made by chemical analysis of the paper.

11. Alkaliproofness. Paper for wrapping or lining soap must show good resistance to staining by the alkali in the soap. In some cases an absorbent inner liner is used to protect the appearance of the outer wrap. The test is made by spotting the sheet with alkali solutions of various concentrations, also by actual sweat tests on the soap itself.

12. Permanence. In books and printed documents, it is desirable that the value of the printed matter is not lost through deterioration of the paper on which it is printed. Permanence is usually tested for by measuring the rate of decline of folding endurance when heated at 100° C. The paper is heated to accelerate loss of strength.

This test brings out the fact that the purer pulps such as rag and high alpha have the highest degree of permanence, then ordinary bleached pulps, then low alpha bleached stock, followed by unbleached pulps. Highly lignified fibers, such as groundwood, have the lowest degree of permanence. It has also been found that the pH of the sheet exerts a powerful influence. Dropping the pH of the sheet from, say 5.5 to 4.4, greatly lowers its stability and accelerates loss of strength in storage.

Summary

In order to summarize for reference the foregoing list of the forty-four most useful properties of paper, we have tabulated them as shown in Fig. 149

Relationship of Tests to Operating Variables

Fig. 150 illustrates the steps that would be taken to duplicate a sample of waxed paper. On the left hand side are shown the qualities of wax and the waxing procedure necessary. On the right hand side are shown the various base stock characteristics ordinarily tested for and the various details of beating, jordanning and paper machine operation affecting these properties.

Tolerances

Having determined the special properties it is necessary to embody in a sheet of paper, the next step is to determine what tests shall be made and what tolerances or limits shall be specified for these tests.

This question of knowing exactly what differences are significant is one of the biggest problems in interpreting paper tests. When the limits are properly defined, certain alterations in raw materials and processing may be allowed and so long as the required test limits are complied with, the paper should continue to meet the customer's requirements. Sometimes tolerances are set up that make it unnecessarily tough for the papermaker and this, of course, is poor business both from the standpoint of machine

production and operating economy. However, the limits must be sufficiently narrow to guarantee continued uniformity from run to run.

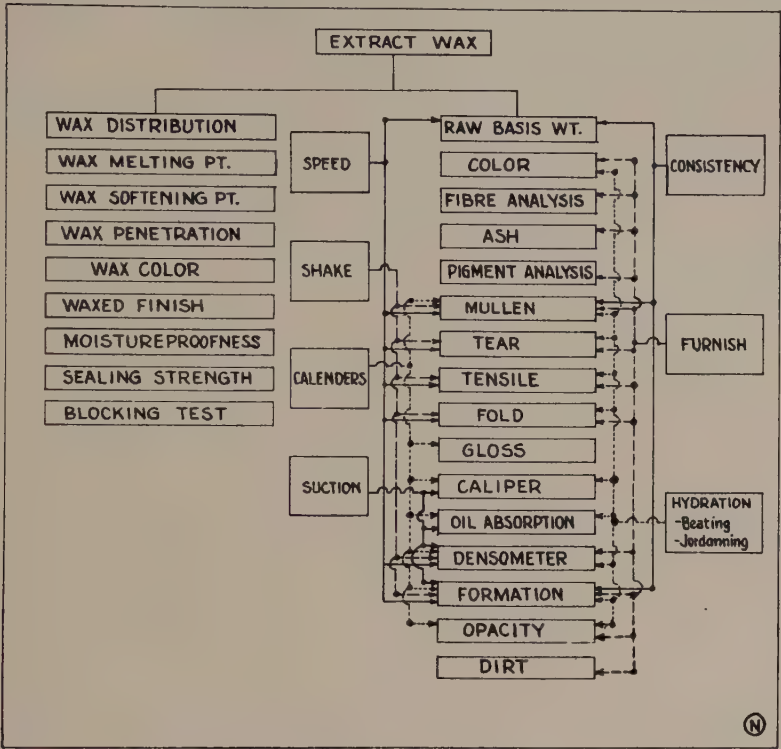


Fig. 150 Steps in Duplication of Waxed Paper Sample

It is illogical to hold within limits that are less than errors in testing instruments, variations from point to point in a roll or the capability of machines or machine crews. In order to minimize the effect of these variables as much as possible, a number of tests are usually made and averaged, the actual number of determinations depending on the accuracy of the test itself and the fluctuation of the particular characteristic in question across the web.

Tests vary a great deal in their ability to average variation. Basis weight, measured on a 24 x 36 sample, may be considered to fairly well average up local variation on small areas. Tearing strength, usually made on sixteen thicknesses of paper, also pretty well averages strength fluctuation from point to point. Folding endurance, on the other hand, measures only a small area about 1/16" wide by 3/8" long. For this reason, standard TAPPI testing procedure requires averaging ten folding tests but only

requires making five tearing tests. In the case of some tests, such as Mullen, caliper, gloss and opacity, the ease and speed of making the test justifies making a larger number of determinations than with the more time consuming tests such as moisture, tear, tensile or fold.

The Institute of Paper Chemistry at Appleton has found that percentage Mullen varies with the basis weight, therefore Mullen expressed as pounds per square inch is a better figure than the percentage value. In the case of tearing strength, the test increases much more rapidly than the weight, so "percentage tearing strength" cannot be used, and the absolute value in grams is the only reliable measurement for comparing papers of different basis weight.

Printing Papers

Printing and publishing absorbs more paper in this country than any other single outlet. For this reason, largely, a great deal of study has been given to pressroom requirements by mills manufacturing printing papers. Printers require paper that will operate without interruption in high speed presses, faithfully reproduce printed designs with freedom from strike-through and show-through, and accomplish this with low ink costs. Some of these requirements, such as the necessity for strength yet a smooth soft surface, cover more or less opposing qualities which have taxed the ingenuity of the paper manufacturer to provide. The ink manufacturer has been drawn more and more into the picture until today the responsibility for successful pressroom operation is pretty well evenly divided between the printer, ink maker and paper manufacturer.

Foodstuffs Papers

The food industries are the second largest users of paper products. In the past, staple products were usually packed and displayed in wooden boxes and barrels. This is now becoming obsolete in favor of smaller attractively designed units as, for example, the packaging of dried fruits. These smaller containers improve freshness, sanitation and general quality of the product and allow it to be better identified by trade name.

Not so many years ago the Chinese vegetable peddler with his horse and wagon used to be a familiar sight on our city streets, but with advances in intensive scientific cultivation, new methods of packing and marketing, and faster distribution systems, the "one-horse" hand to hand distributor has gradually disappeared. Paper has a definite place in this changing picture and its improvements are keeping pace with new developments in the fruit and vegetable industries. Oranges, lemons, grapefruit, apples, tomatoes and pears are now scientifically wrapped and even the lowly potato has lately been glorified by an attractive printed wrapper. Vege-

table crate liners, plant covers, box liners, pear and apple pads, and new liners and wrappers for dried fruits are examples of agricultural paper grades that are continually being improved. Along with this development have come improvements in packaging machinery that can now set up boxes, line, fill, weigh and wrap them in one operation.

The chief requirements of a food package are:

1. Physical protection of contents. Protection against sifting, handling, contamination and insect infestation.
2. Protection against loss of quality. Resistance to gain or loss of moisture, loss of volatile flavors, and absorption of foreign odors. Resistance to grease penetration as in packaging of mayonnaise, butter, peanut butter, etc., and to penetration and staining by fruit juices.
3. Eye appeal—gloss, transparency, opacity, whiteness and color design features.
4. Convenience—as to size and shape.
5. Shelf life considerations—fading of color, mechanical stability, etc.
6. Processing and storage conditions—as, for example, in packaging foods for freezing and packaging of hot fruits.

The baking industry uses a considerable amount of paper chiefly in the form of printed waxed bread wraps. Approximately \$700,000,000 worth of bread is sold each year in this country and practically all of this is

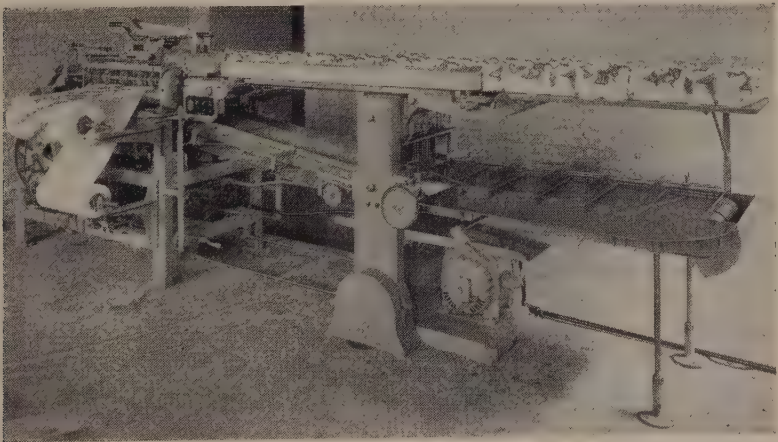


Fig. 151
Bread Slicing Wrapping Machine

wrapped. The trend in bread wrapping has been toward a transparent sheet like cellophane, transparent waxed papers and self-sealing lacquered glass-

ines at one extreme and to opaque high white wrappers at the other extreme. The bulk of bread is at the present time packaged in opaque wrappers. The chief requirements (apart from cost considerations) for such a sheet are that it has good strength, good appearance and satisfactory sealing qualities. From the converter's standpoint, it must also print well, have properly controlled wax absorption, have a certain caliper value to give it "body" and be pliable. Fig. 151 illustrates a modern machine for automatically slicing and wrapping bread.

The fresh fruit industry absorbs large amounts of paper. In the Northwest alone the fruit crop requires something like 350 cars of paper each year. Oiled fruit wraps are used to control "scald" in packed apples. Paper is treated with a pure mineral oil substantially free from odor, taste and color which absorbs the gaseous respiration products of the fruit. These gases, unless absorbed, would become concentrated and kill or "scald" the skin, making the affected areas susceptible to rapid decay when the fruit is brought out of cold storage. The oil is used at certain concentrations in the paper and the proper viscosity and specific gravity requirements have been carefully worked out.

Fruit wraps, chiefly citrus tissues, have to be soft and pliable, have a clear brilliant color, and must be strong enough to resist splitting in wrapping. The most critical strength requirement is the cross direction tensile test.

A large amount of paper is used each year in packaging dried fruits. Of the dried fruit industries, the packaging of raisins is of primary interest since the Pacific Coast is the most important raisin producing center in the world.

The dried fruit industry has its beginnings lost in the dim pages of history. King David of Israel accepted raisins as payment of taxes and in 430 B.C. a Babylonian mortgage, the earliest known document of its kind, called for payment of principal and interest in dried fruit. Dried peaches are mentioned in the writings of Confucius.

Starting in the East, the dried fruit industry has gradually migrated westward until at the present time the largest proportion of raisins produced in the world are made within 100 miles of Fresno in California. In 1878, the California crop was 500 tons, and in 1930 it was 25,000 tons, showing the growth of the industry.

About 25 years ago, the first paper trays were used to dry raisins. Now over 80 percent of all raisins produced are dried on paper trays which are cheaper than wooden trays and can be discarded at the end of each season. Raisins are packed in paper cartons with specially treated paper liners and wrappers. This company has been closely identified with the

development of special paper grades for the requirements of the raisin and other dried fruit industries.

Another expanding use for paper is in the manufacture of paper milk bottles. This is of timely interest since this type of container is now being introduced on the Pacific Coast in the San Francisco Bay area. Many large distributors are already handling a large volume of their business in New York and other Eastern cities in paper milk bottles. In addition to requirements for strength, stability and leakproofness, paper for milk bottles must be sterile, and Public Health authorities are very insistent on this point. The majority of samples now in use show, by actual test, bacterial colony counts of less than 250 per gram. The count should not exceed 500. In some instances, paper has shown counts of from 5,000 to 50,000 per gram, and such paper is entirely unfit for perishable foods. Control of bacteria depends mostly on a clean water supply and in keeping machine systems sterile and slime free. This involves a knowledge of predominating organisms encountered and how to control them.

Camas already makes a large variety of foodstuffs papers and is in an excellent position to make such exacting grades as milk bottle paper, using only virgin bleached pulp, chlorinated water supplies and with a well regulated system of slime control.

Versatility of Paper

Paper is becoming an extremely versatile fabricating material. In addition to its ordinary uses, it is used in making table cloths, doilies, napkins, towels, dishcloths, handkerchiefs, twine, carpets, collars, belts, window shades, overcoats, umbrellas, slippers, shoes, hats, bed sheets, blankets, pillow cases, milk bottles, pie plates, forks, spoons, garden furniture, gears, shingles, dusting paper, shower mats, electrical conduit, artificial leather, buttons, oil cans, combs, cigar boxes, megaphones, moth-proof bags, berry boxes, cuspidors, waste paper baskets, suitcases, book ends, lamp shades, bandages, diapers, barbers' and dentists' head rest paper, chest protectors, bags for radios, automobiles and furniture, adhesive tape, garbage bags, finger bowl liners and noiseless paper for movie and radio. New uses are being developed almost every day. Paper dishes are now being extensively used in Russia.

The Consumer Viewpoint

Of late years, many customers have shown a keen interest in efforts to control use requirements by paper testing and many of them have installed fairly complete equipment in their laboratories for testing the paper they buy. Some of the largest bakers on the coast, for example, are now testing their bread wrappers.

In the past, efforts to properly define use requirements have been hindered by—

1. Inability of the consumer to properly define his requirements or a lack of understanding on the part of the manufacturer as to how to interpret these requirements in papermaking terms.
2. Fear of the manufacturer that he will be tied down to a disadvantageous position if the quality of his product is too carefully defined.

Fortunately much of the mystery has been taken out of dealings between producer and buyer of paper and more of a feeling of mutual confidence has developed. In the last analysis, the paper must do the job and if it won't then its specifications are wrong and must be changed.

Mill executives are becoming more and more interested in the outlets for paper as converted products and a much closer cooperation has developed between mills and converting units in the past few years. Paper, instead of being a finished product, is now largely a raw material for the expanding converting industries.

A standard of quality merely represents an understanding between producer and consumer regarding the service merits of the commodity. Such standards must be primarily performance standards written from the consumer's point of view and not the manufacturer's. Paper manufacturers can find no surer way of convincing their customers that their products are of uniformly high quality and thereby building up a feeling of confidence, than by showing them that their tests and specifications are really designed to control performance.

Sometimes a customer takes the stand that if one manufacturer can not supply paper for his requirements, somebody else will. Very often this is asking too much but many times it is the truth. Manufacturers today are constantly striving to better understand their customer's needs to the end that a fully satisfactory grade can be supplied and the undesirable condition of dissatisfaction and complaint eliminated. Sometimes this proves to be a difficult task, and the responsibility for developing grades for special requirements must be jointly accepted by producer and consumer if the best results are to be realized.

CHAPTER XXVIII

PAPER GRADES AND SPECIFICATIONS

By F. A. OLMSTED and M. K. RAWLINGS

The Camas mill manufactures a multiplicity of paper grades, covering a wide range of basis weights, colors and sheet characteristics under greatly varying manufacturing conditions, and must necessarily be equipped with a convenient system of indexing and an adequate specification system upon which largely depends the successful maintenance of uniform quality.

Grades are made in basis weights ranging from 9-pound tissue, such as is used for florist wrap, up to 175-pound board used in the manufacture of salesbook covers. Including all basis weights and colors, there are over a thousand grades made at the Camas mill.

Aside from the wide range of basis weights and colors, the Camas mill operation embraces diversified pulp furnishes which include various mixtures of unbleached kraft, several degrees of semi-bleached kraft, unbleached sulphite, several grades of bleached sulphite, and several grades of groundwood.

All of this, added to the fact that these many paper grades are made on twelve paper machines, no two of which are exactly alike, emphasizes the necessity of having very complete records that cover not only the quality and characteristics of each sheet, but also the different materials which enter into its manufacture, and the important sheet requirements from a sales standpoint.

Camas Paper Grades

For indexing the grades, the accounting department has assigned a group of numbers which have been divided and subdivided to provide a numerical designation for each grade.

The following is an outline of the Grade Manufacturing Code, which is the name by which the grade index is now known:

1100 Group—Groundwood Papers, News Grade

Includes all paper of newsprint furnish and quality which contains not less than 70 percent groundwood pulp, balance unbleached sulphite.

1110—Newsprint Paper.

1120—Poster Paper.

- 1130—Tablet News.
- 1140—Wrapping News.

1200 Group—Groundwood Paper Specialties

Includes groundwood paper which differs from newsprint in pulp furnish or quality.

- 1210—Board Lining News.
- 1220—Catalog and Directory.
- 1230—Magazine.
- 1240—Rotogravure.
- 1250—Carbonizing.
- 1270—Groundwood Book.

1400 Group—Unbleached Kraft Paper

Includes all grades containing over 50 percent unbleached kraft pulp with the exception of Kraft Towelling (1900), Semi-Kraft Towelling (1900) and Damask Alfibre Bag and Wrapping (1600).

- 1410—Kraft Butcher.
- 1430—M. F. Kraft Wrapping.
- 1440—M. F. Kraft Bag.
- 1450—M. F. Kraft Converting.
- 1460—M. G. Kraft Wrapping.
- 1470—M. G. Kraft Bag.
- 1480—M. G. Kraft Converting.

1500 Group—Bleached Kraft Paper

Includes all fully bleached and semi-bleached kraft papers, except Damask Alfibre (1600).

- 1510—M. F. Bleached Kraft Butcher.
- 1530—M. F. Bleached Kraft Wrapping.
- 1540—M. F. Bleached Kraft Bag.
- 1550—M. F. Bleached Kraft Converting.
- 1560—M. G. Bleached Kraft Wrapping.
- 1570—M. G. Bleached Kraft Bag.
- 1580—M. G. Bleached Kraft Converting.

1600 Group—Unbleached Sulphite Paper

Includes all unbleached sulphite grades not otherwise specified, including mixed furnish papers. Also includes Envelope Manila, Drawing Manila, Damask Alfibre, Crown Satina Alfibre Bag, Core Paper and Sulphite Mill Wrapper.

- 1610—Sulphite Butcher.

- 1620—Sulphite Manilas.
- 1630—M. F. Sulphite Wrapping.
- 1640—M. F. Sulphite Bag.
- 1650—M. F. Sulphite Converting.
- 1660—M. G. Sulphite Wrapping.
- 1670—M. G. Sulphite Bag.
- 1680—M. G. Sulphite Converting.
- 1690—Oiled M. G. Sulphite Wrapping.

1700 Group—Bleached Sulphite Papers

Includes all 100 percent bleached sulphite papers not otherwise specified, including Transparent Bleached Sulphite. Does not include Envelope Manila (1600).

- 1710—Bleached Sulphite Butcher.
- 1720—Opaque Bread Wrap.
- 1730—M. F. Bleached Sulphite Wrapping.
- 1740—M. F. Bleached Sulphite Bag.
- 1750—M. F. Bleached Sulphite Converting.
- 1760—M. G. Bleached Sulphite Wrapping.
- 1770—M. G. Bleached Sulphite Bag.
- 1780—M. G. Bleached Sulphite Converting.
- 1790—Oiled Bleached Sulphite Wrapping.

1900 Group—Jumbo Toweling

All towelling stock, bleached or unbleached, kraft or sulphite, is included in this group.

- 1920—Bleached Sulphite Towelling.
- 1930—Unbleached Sulphite Towelling.
- 1940—Semi-Bleached Kraft Towelling.
- 1950—Unbleached Kraft Towelling.

2000 Group—Fruit Tissue

All Fruit Tissue, including L. A. Tissue, is run in jumbo rolls in this group.

- 2010—M. F. Unbleached Dry Fruit Tissue.
- 2020—M. F. Unbleached Oiled Fruit Tissue.
- 2030—M. F. Bleached Dry Fruit Tissue.
- 2040—M. F. Bleached Oiled Fruit Tissue.
- 2050—M. F. Copperized Fruit Tissue.
- 2060—M. G. Unbleached Dry Fruit Tissue.
- 2070—M. G. Unbleached Oiled Fruit Tissue.
- 2080—M. G. Bleached Dry Fruit Tissue.
- 2090—M. G. Bleached Oiled Fruit Tissue.

2100 Group—Wrapping Tissue

All bleached or unbleached wrapping tissue, toilet tissue and napkin stock are run in this group.

2120—Toilet Tissue.

2130—Napkin Stock.

2140—Waxing Tissue.

2160—M. F. Unbleached Tissue.

2170—M. G. Unbleached Tissue.

2180—M. F. Bleached Tissue.

2190—M. G. Bleached Tissue.

Code Numbers

Under the code system it is, of course, necessary to subdivide these general group classifications and supplement them with further numbers by which any individual sheet may be completely identified. For this purpose the first subdivision is in the code group number itself, by which the primary classification of the grade is made. Following this, a second number is used arbitrarily to indicate any variation in the quality, test, furnish or finish of that grade. The basis weight of the sheet provides a third number and a color code number completes the entire specification or code number. For example, 48-pound Golden Brown Sweat Finish Waxing Kraft would be listed in the grade manufacturing code as 1452-2-48-429. This number is analysed as follows:

1452	Crown Waxing Kraft.
2	Sweat Finish.
48	Basis Weight.
429	Golden Brown.

The numerous color standards are indexed separately and are divided into eight color groups as follows:

1. Bleached White. The word "Bleached" does not necessarily mean that bleached pulp has been used, but is merely the type of white commonly associated with Bleached Sulphite Sheets.

2. Unbleached White. The word "Unbleached" does not necessarily mean that unbleached pulp has been used, but is merely the type of white commonly associated with Unbleached Sulphite Sheets.

3. Yellow

4. Brown.

5. Green.

6. Blue and Purple.

7. Red and Pink.

8. Black and Gray.

9. Orange.

The first digit of the color code number designates the color group to which the standard belongs, but the following digits are arbitrarily chosen and have no reference to any characteristic of color, furnish or use of the sheet.

A set of specifications must so describe and define a sheet of paper that it can apply to no other sheet, and the preparation of these requires specific and detailed information about the various grades that are being manufactured. This information is compiled and specifications are prepared by the Technical Department.

Among the first questions to arise are, upon what are specifications based, what are the things that determine the required characteristics of a sheet of paper, and from where is this information derived. Paper is made to sell in a definite market, consequently the source from which all specifications have to be derived is the market requirements. In the case of some types of paper, this merely means general trade custom. The trade demands a certain paper, having definite qualities and characteristics. In other cases, it is necessary to meet the particular requirements of a particular customer, and these requirements are sometimes very definitely described within narrow limits. In any case, it is ultimately the customer's requirements that really serve as a basis on which all specifications have to be drawn, for the simple reason that the customer is the one who has to use the paper, and in order to sell him it is necessary to supply that which will suit his use. Specifications that will be the easiest to meet cannot be established for a sheet of paper nor specifications that will best fit manufacturing requirements, except as these come within the requirements of the customer.

In this matter of specifications, therefore, the first contact that the Technical Department has is with the Sales Department. The information on which specifications are based primarily comes from or through the Sales Department. The Technical Department acts as agent of the Sales Department in its relationship with the mill, stating what characteristics are necessary in every sheet. Having these characteristics, the manner in which a particular type of paper can be made to meet these requirements and the necessary manufacturing conditions involved are taken up with the Operating Department. The Technical Department thus acts as an intermediary between Sales and Operating Departments.

When the paper is being made, the necessary tests are made to determine whether or not the paper meets the requirements which have been specified. This serves a double purpose. In the first place, based upon these tests, the Technical Department says whether or not the paper is suitable for shipment, but it is also a service to the Operating Department, giving information regarding the quality of sheet being made and making it

possible to apply corrective measures, if something is wrong, before a large quantity of defective paper is produced.

It may be said, therefore, that in its relation to the Sales Department, the Technical Department first acts as its agent in the matter of preparation of specifications, and again, after the paper is made, it also acts for the Sales Department in determining whether or not the paper is acceptable for shipment. For the Operating Department it first sees that unreasonable or impossible requirements are not incorporated in the paper specifications, and then it tells them while the paper is being made how the paper on the machines conforms to the specified requirements.

Specification Forms

With any such number of grades of paper to be covered by specifications as are made at Camas, it is necessary to have forms which cover all of the various tests which define the quality of the sheet.

The first form to be considered is the shipping specification (see Fig. 152) giving the range in quality and tests which is required to meet customer requirements. In the upper right hand corner, space is provided for the specification number, the date on which it is prepared and the number of the paper machine on which the paper is made. There are also references to the corresponding manufacturing and quality control specifications and a space showing the date of a former issue which the current specification may replace. Then there is the space provided for the name of the grade and the name of the customer. On the left hand side of the sheet are enumerated the various tests which are used to measure the quality of the grade, and two blank columns, the first headed "Specified Average," and the second, "Shipping Limits." In the first of these columns is shown the average requirements for such of the characteristics as are pertinent to the particular use of the sheet in question. Naturally all of the tests cited are not made on all papers. Some require very few tests, while the characteristics of other sheets are so rigidly defined that many of them have to be specified. All of them are never used in connection with any single grade.

In the column headed "Shipping Limits" is shown the extreme range in tests which is acceptable to the trade or the customer. Any paper which does not test within these specified shipping limits must be held and diverted to some other purpose, or returned to the beaters, if no other outlet can be found for it. A space is also provided for color, finish and formation. Under color is shown the numerical key for the standard color sample to which paper is to be run, and it is the duty of the Sample Department to see that the operators and paper testers are supplied with standard

PAPER SHIPPING SPECIFICATIONS

Crown Zellerbach Corporation—Mill _____

This is a Contract

Specification No. _____

Ref. Mfg. Spec. No. _____

Ref. Quality Control No. _____

Machine No. _____

Date _____

Replaces Issue of _____

Date First Made _____

GRADE _____

CUSTOMER _____

	Specified Average	Shipping Limits	FURNISH per beater _____ lbs. Stock
Basis Weight 24x36—480			
Moisture %			
Mullen %			
Caliper Reel Inches			
" Winder "			Size
Tensile W.M.D. lbs.			Alum
" C.M.D. "			
Tear W.M.D. gms.			
" C.M.D. "			Anilines
Fold W.M.D.			
" C.M.D.			
Stiffness W.M.D. mgs.			
" C.M.D. "			
Densometer—Seconds			
Oil Absorption %			Beating and Jordaning
Sizing—Seconds			
Flotation "			
Ink Test Minutes			Machine Speed
Ash %			Finish 1st Stack Nips
Oil Content %			2d " "
Transparency %			3d " "
Opacity Raw %			Sweat
" Oiled %			Water Boxes 1st Stock
Gloss Wire Side			2d "
" Felt Side			3d "
Color			
Finish			
Formation			

SPECIAL NOTE:

Prepared by _____ Approved _____ Technical Supervisor

Approved _____ Approved _____ Sales Production Dept.

Standard Samples Attached

(Fig. 152)

MANUFACTURING PAPER SPECIFICATIONS

Crown Zellerbach Corporation—Mill _____

GRADE _____ Specification No. _____
 Machine No. _____
 Date _____
 CUSTOMER _____ Replaces Issue of _____

PAPER SPECIFICATIONS	FURNISH per Beater _____ lbs. Stock _____
Basis Weight—24x36—480	
Moisture %	
Mullen %	
Caliper Reel Inches	
" Winder "	Size
Tensile W.M.D. lbs.	Alum
" C.M.D. "	
Tear W.M.D. gms.	
" C.M.D. "	Anilines
Fold W.M.D.	
" C.M.D.	
Stiffness W.M.D. mgs.	
" C.M.D. "	
Densometer—Seconds	
Oil Absorption %	Beating and Jordaning
Sizing—Seconds	
Flotation "	
Ink Test—Minutes	Machine Speed
Ash %	Finish 1st Stack Nips
Oil Content %	2d Stack Nips
Transparency %	3d Stack Nips
Opacity Raw %	Sweat
" Oiled %	Water Boxes 1st Stack
Gloss wire side	2d "
Gloss felt side	3d "
	Packing
Color	
Finish	
Formation	

SPECIAL NOTE

Prepared by _____

Approved _____

Paper Mill Supt.

Technical Supervisor.

Standard Sample Attached

(Fig. 153)

color samples to correspond. Under finish and formation is stated as definitely as possible the particular characteristics required, and how closely a product meets these requirements is determined by comparison with approved standard samples which are attached to the specifications.

On the right hand side of the sheet, provision is made for a record of the furnish used for the paper in question and some of the more general operating conditions such as time of beating, machine speed, calender finish, etc. The information shown in this section is not only a guide for the manufacture of the paper, but also furnishes the Sales Department with data from which to estimate its cost.

Below these more detailed specifications is a section headed "Special Notes." In this section are written particular instructions or comments which may be required to give full understanding of the qualities desired, both in general and also by any particular customer, and possibly the relative importance of certain tests. Reference also is made here to any instructions or correspondence upon which the specifications have been based.

At the bottom of the sheet is recorded the name of the person preparing the specifications, and space for approval by the Technical Supervisor and a representative of the Sales Department. It is also the practice to have specifications initialed by any others who have particular interest in, or are in any measure responsible for, the quality of the paper described.

The Manufacturing Specification (see Fig. 153) has practically the same headings and lists the same tests and operating requirements as the shipping specification. In the manufacturing specification, however, the limits shown in connection with the various tests, represent the range that will be considered satisfactory and give paper of standard commercial quality. These limits may occasionally correspond exactly with those given in the shipping specification, but in most instances the specified manufacturing range is a little narrower, and paper within the limits shown in this range is of entirely satisfactory quality. It may be, too, that more tests are shown as being required on the manufacturing specifications than on the shipping specifications. This is because there are certain tests which indicate rather important contributing characteristics but upon which actual shipability of the paper is not based.

The data regarding furnish and operating conditions shown in these specifications are, of course, identical with those given in the shipping specifications. The information given under special notes includes any special information for the guidance of the Operating Department and comments on the character of sheet required. Here also is shown reference to the sources of information or instructions upon which specifications are

STANDARD QUALITY CONTROL SPECIFICATIONS

GRADE		Date Issued	QUALITY RATINGS	
Customer or Use:		Replaces Issue of	Grade A	Grade B
		Ref. Mig. Spec. No.		
Basis Weight—24x36—480				
Moisture %				
Mullen %				
Caliper	Reel	Inches		
"	Winder	"		
Tensile W.M.D. lbs.				
"	C.M.D.	"		
Tear W.M.D. grs.				
"	C.M.D.	"		
Fold W.M.D.				
"	C.M.D.	"		
Stiffness W.M.D. mgs.				
"	C.M.D.	"		
Densometer—Seconds				
Oil Absorption %				
Sizing—Seconds				
Flotation "				
Ink Test—Minutes				
Ash %				
Oil Content %				
Transparency %				
Opacity Raw %				
"	Oiled	%		
Gloss Wire Side				
Gloss Felt Side				
Color				
Finish				
Formation				

(NOTE: Fig. 154)

Prepared by _____
 Approved _____
 Approved _____
 Mach. No. _____
 Serial No. _____

Grade _____

WATER CREPE PAPER SPECIFICATIONS

CROWN-WILLAMETTE PAPER COMPANY — CAMAS

Specification No. _____ Prepared by _____

Date Issued _____ Approved by _____

Replaces _____ Approved by _____

Grade _____

Customer _____

Use _____

Paper Required

Grade _____

Specification No. _____ Mfg. _____ Quality _____

Color _____

Basis Weight _____

Caliper _____

Creping Specifications

Character of Crepe _____

Basis Weight after Creping _____

Moisture " "

Caliper " "

Stretch " "

Finishing Requirements _____

SPECIAL NOTES—

Serial No. _____

Grade _____

Standard Sample Attached

(Fig. 155)

LAMINATED PAPER SPECIFICATIONS

CROWN-WILLAMETTE PAPER COMPANY — CAMAS

No. _____

Prepared by _____

Date Issued _____

Approved by _____

Replaces. _____

Approved by _____

Grade _____

Customer _____

Use _____

Paper Required

Grade _____

Specification No. _____

Mfg. _____

Quality _____

Color _____

Basis Weight _____

Laminating Specifications

Laminating Material _____

Amount Required _____

Basis Weight of Laminated Paper _____

Caliper of Laminated Paper _____

Moisture Proofness _____

Finishing Requirements _____

SPECIAL NOTES —

Sheet must be hard from edge to edge—

Serial No. _____

Grade _____

Standard Sample Attached

(Fig. 156)

based. The manufacturing specification is signed as being approved by the paper mill superintendent and the technical supervisor and is also initialed by other interested parties.

In addition to the shipping and manufacturing specifications, standard Quality Control Specifications are used in connection with every grade. This form (see Fig. 154) lists the same tests as are shown on the two first named specifications and at the right hand end of the sheet has two columns for quality ratings headed Grade A and Grade B. In the body of the form are listed the specified average requirements for each basis weight for any grade. The Grade A column gives the limits for the best possible paper, or paper that may be considered perfect, and Grade B describes the limits outside of this range which, though not perfect, are still considered commercially acceptable. The total range of tests included in Grade A and Grade B corresponds to the limits shown in the manufacturing specification. This form also shows the name of the grade, the customer or use of the paper, the date on which the specifications are issued and that of the former issue which it replaces. The paper testers make their tests on samples taken from every reel of paper made on the machines and grade the quality of the sheet in accordance with these quality control specifications.

A special specification form is used for Water Creped papers made on the creping machine (see Fig. 155). Here, space is provided for a general description of the grade of paper being used for creping, and for the creping specifications, including character of the crepe, basis weight, moisture, caliper, and stretch after creping. Then too, there are specifications for Laminated papers (see Fig. 156) in which are shown the character of the paper to be laminated and the laminating requirements. These specifications include the material used for laminating, the amount of laminating material required, basis weight, caliper and moisture-proofness of the finished product. Attached to each of these specifications are standard samples of the product described therein.

Maintenance of Specifications

The methods used in the preparation and revision of specifications might be considered under three classes, as follows:

1. The minor revisions that are made from time to time as a result of more perfect understanding of the requirements as obtained from daily observation.
2. The more general revisions which may be called for by a change in customer requirements.
3. The development of suitable specifications for an entirely new grade.

Revisions of the first type are taking place continually. It may be found in the course of daily operating practice that some particular requirement on the sheet cannot be met in the manufacturing process or does not quite meet the requirements of the customer who is going to use it. Complaints and customer reports frequently indicate some slight change that is desirable. Some of the paper is used in the bag factory and converting plant, and something may come up in one of these departments that shows where an improvement can be made. Then too, it is frequently found that some requirement is more rigid than it needs to be, and the specifications are modified correspondingly. If it is found, for instance, that a wider range in some particular test can be used without affecting the ultimate value of the paper to the user, that wider range is introduced in order to make it easier for the paper machine crew to make satisfactory paper. This must be done cautiously, however.

Every now and then there occurs the necessity of revising specifications to meet some new trade condition or customer requirement. This involves a more general revision than those mentioned above. Under such conditions, it is necessary to issue new specifications and print across them the word "TENTATIVE." By doing this it becomes recognized by all concerned that the sheet in question is for the time being in a stage of development, that the Operating Department does not necessarily agree to make paper in strict conformity with these tentative specifications, and that further revisions in specifications may be expected as a result of information derived from current operations and customer reaction.

When an order is received for a grade that has not been made before, the first consideration is to find out what the requirements are for the paper. The customer may be able to supply this information, but more commonly all he is able to do is to supply a sample of the paper he wants and explain the purpose for which it is to be used. This sample must then be submitted to analysis and test. First may be a microscopic analysis to determine the fiber furnish used, then various physical tests to ascertain what particular requirements should be specified. From the results of this investigation temporary specifications are set up and are marked "TENTATIVE," to indicate that the matter is in the development stage.

In connection with the first run of this paper a complete study of operating conditions is made and an operating report rendered, giving a record of what has actually been done. Then, after the paper has been shipped, the customer's reaction is obtained through the Sales Department in order to make sure that the sheet is satisfactory for the use intended. In this way the Technical Department may be prepared to set up standard specifications before making another run of the paper, or it may be necessary to keep the specifications on a tentative basis, making changes from

time to time, until several runs have been made. Eventually, however, standard manufacturing conditions and requirements are determined and standard specifications are established.

SAMPLE DEPARTMENT

Service to the Mill

In connection with the development of specifications, the Sample Department has an important function; that of obtaining standard samples and keeping them available to the operating departments. For each grade that is made, a supply of standard color samples is filed in the Sample Department and when a subsequent run is made the color sample is issued to the beater room, the paper testing station and the laboratory, so that a close check may be made on the color of the run. Since spectral reflectance measurements are recorded for each color sample, careful observation and periodic checking of the standards provides a guard against variation from run to run and reveals any tendency toward gradual color retrogression of the sample stock.

Also, a supply of standard finish and formation samples is kept available and these are issued to the paper testers and machine crews for comparison with current manufacture.

Outturn Samples

Samples are taken daily from each grade made during the preceding 24-hour period. These are sent to the various Sales and Executive offices.

Service to Sales Department

The Sample Department has as its first duty the stocking of all grades including the various basis weights and colors, for the use of the Sales Department in introducing the products to customers. Samples of average quality are obtained from the mill and kept in light-proof boxes in the Sample Department where regular sample department orders are filled. These orders frequently call for swatches of standard grades of paper, bags, toilet tissue or towels, and, in some cases, a combination of these, so the activities of the Sample Department must extend into the bag factory, converting plant and printing department.

Records

Valuable records are kept in the sample department including a history of every standard color sample, and a brief record of every machine run, including the date of the run, order and program numbers, specification number, color number, and any special remarks that may prove to be of interest later on. These records are kept in such a way that the sample department can quickly supply information regarding any run of paper made since this record has been in use. The samples used by paper testers in the course of regular testing routine are also filed for future reference.

CHAPTER XXIX

THE PERSONNEL DEPARTMENT

By V. C. GAULT

The salient factors in industry are symbolized by the letter "M"—Materials, Money, Manufacturing, Management, Markets and Men. The personnel department is primarily interested in men which are considered to be by far the most important of all these M's.

Industry in its early days was mostly a family affair. The craftsman depended on his family and relatives for help and needed no outsiders. As demands for certain products increased, partnerships between families were formed, and if there were not enough people in their families to run the business, friends and neighbors were called in. With the development and application of machinery to industry, small business gradually merged into centralized plants and with resulting increases in volume of production, the employment of outsiders soon overshadowed the original family plan. Thus the employment of men became an important phase of industrial operations.

The world war upset many ideas. The combination of peak production and labor shortage demonstrated forcibly the importance of labor to industry and the old ideas of handling labor went overboard. A new conception of personnel relationship was evolved—the study of men as individuals with a more sympathetic understanding of their problems.

This company has always enjoyed the reputation of square dealing with its men. This grew out of the time when the plant was smaller and relations between the men and the mill executives were more personal than it is possible to have in a plant the size of Camas mill today. In those days, too, the employment and instruction of the men was done by the department heads. Later, however, to keep pace with expansion, it became necessary to handle all labor problems through a central personnel department. This met with an unfavorable reaction from some department supervisors who thought that part of their responsibility was being taken from them. However, superintendents soon became enthusiastic supporters of centralized personnel work because it gave them more time to devote to quality, production and costs.

It is impressed on every new employee that he has a direct responsibility in the production of profit for the company. On him and his fellow

workers the company executives depend on whether or not dividends will be available to the investors who, in the last analysis, make his job possible. Unless a business produces a profit, investors will withdraw their capital and the concern simply closes its doors.

It has been said that labor and capital are diametrically opposed in their viewpoints. It has also been said that the personnel department represents capital and therefore could not possibly be sympathetic to labor. Both of these statements are wrong. This may be illustrated by a simple example.

Suppose that a rancher has a barn on his ranch and has bought a new door to replace a broken one. While he is standing there figuring on how to get the job done, a stranger comes down the road, stops, and offers to do the job for him. The terms are agreed upon and the stranger exchanges labor for money. The rancher furnishes the capital outlay, the new door, hinges, screws, plane, saw and screw driver. If there were no door and no tools, the stranger wouldn't be able to sell his labor and if there were no labor the door and tools would not serve their purpose. The rancher is the capitalist, let us say, and the stranger the laborer. Each is dependent on the other to get the job of hanging the door done, and each benefits by what the other has. The same is exactly true of the Crown Zellerbach Corporation which spends millions each year on supplies and capital investment, and pays some \$13,000,000 annually to 8,300 employees who, in their turn, contribute the necessary labor to keep the wheels turning. The corporation, like the rancher with his door and tools, has about \$12,000.00 invested for each employee on its payroll. Without this investment, there would be no payroll.

Other industries show similar relations. The automobile industry has \$2,000.00 invested in plant and property and some \$2,500.00 in machines and equipment to provide employment for one man.

So labor and capital are mutually dependent on each other and for the good of the industry, both groups must pull together.

Another erroneous idea is that labor suffers from new inventions. However, experiences in industry do not bear this out. For example, about 50 years ago the Mergenthaler Linotype was invented and had the immediate effect of replacing five hand typesetters for each machine installed. However, from that time up to 1930 the population of the country had just about doubled yet employment in the printing industry had increased 500%, without taking into consideration workers employed in ink making, bookbinding, papermaking and other industries accessory to printing.

We hear also that improvements in high speed machine production result in unemployment. While this may be true in a few specific instances,

taking industry as a whole, it is not true. In 1879, 324 people were required to produce the needs of each 1000 of population, while in 1930, 400 workers were required. Furthermore, employment is more nearly normal in the highly mechanized industries such as the automobile and textile industries than it is among the crafts, carpenters, foundry men, etc., where much of the work is still hand labor.

Other chapters in this book follow the course of raw material through the various processing units, likewise is charted the course of a man going through the personnel department.

First of all, the prospective employee is given an interview and asked to answer certain questions in order to determine if he is suitable for the job that is available. One of the first questions asked is where the man lives, as it is the policy of the company to give employment to people residing in this community.

In interviewing men no attempt is made to "over-sell" a job by over-representing its possibilities. It is very harmful to have a man accept a job only to find that it is not a short cut to an executive's desk as he has been told. It is equally harmful to have a man tackle a job and find that he is not mentally or physically able to handle it, so an attempt is made to fit the man to the job and not the job to the man.

If it is believed that the applicant is suited to the job and he makes a favorable impression by his appearance and attitude, he is asked to fill out a Personal Record blank.

A record is made of the first and second names for proper identification, also the former name, if changed. Occasionally, men have previously gone under different names. This also gives a record of female employees who are married or later marry.

Age and date of birth are registered. This is necessary since the state law provides that industry cannot employ a minor after 7:00 P.M.

"Single or Married"—This information is needed for income tax purposes. Also for industrial insurance. If a person is off injured, his rate of compensation is based on whether married or single and number of dependents.

"Other Married Relations"—Divorcees and widows might have children dependent on them.

"Vaccinated"—The reason for asking this is in the event of an epidemic, it could be determined from the files who had been immunized.

"Age, Sex and Relation of dependents other than children."

"Is applicant living with his parents?" These questions are asked because in some cases, the help that an unmarried son or daughter renders

at home would place him in the same class as the head of a family.

"Does applicant own his own home?" Many inquiries are received concerning a man's credit though no information is given out except that the man is employed at the Camas mill and whether or not he owns his own home.

"Insurance"—This information is for the protection of the beneficiary who may not be aware of the insurance.

"If under 21, give parents or guardian's name"—This question is for legal purposes.

"Whom should we notify in case of disability?"—The reason that this question is asked is obvious.

"Social Security Number"—Federal Law requires accurate "Earnings" reports and registration of all workers in this industry.

"For what position is applicant applying?"—This indicates what a man's ambitions and preferences are.

"Education"—This is important, particularly on applications for technical, electrical or mechanical jobs.

"Previous Employment" shows what the applicant's experience has been and furnishes a list of references.

"Character of references"—People who have never employed the applicant. Their statements should be unbiased.

The applicant must sign his legal signature. Every day or so the occasion arises to check up with some authorized person concerning the legality of a man's signature.

Patent Agreement

There are two forms of patent agreements one of which each employee must sign upon entering our services. One of these is for employees of the laboratory in research work, and as they are paid for developing ideas, the entire right to any idea developed belongs to the company. The other form of patent agreement signed by all other employees gives the man certain rights which are not embodied in the one for research employees. Briefly, the patent agreement embodies the following:

Every employee agrees to immediately disclose in full detail all inventions conceived by him while employed by the company, and all improvements to these inventions within two years after leaving the employ of this company. A record will be kept containing this evidence of conception and within 120 days the company will, if interested in patenting the idea,

make a preliminary investigation at its own expense. The company will reserve the use of the patent free of charge in its own plant and affiliated plants. The employee agrees that within 120 days, he will execute application for a patent and assign his entire right and title to the invention to the company. The company bears all the expense of obtaining the patent. In the event the company does not care to take out the patent the employee may patent it in his own name. Nevertheless, the shop right to the use of the invention remains with the company. In the event the patent paid for by the company is sold to a third party, the company agrees to divide on a 50-50 basis with the man the net proceeds from the sale of this invention. In the event the invention is so valuable that the company does not wish to allow it to get into the hands of competitors, then a certain lump sum settlement is provided; also a method of arbitration is provided for arriving at this lump sum if satisfactory terms cannot otherwise be reached. This agreement, of course, only applies to ideas which are applicable to this business.

Special awards are made through the suggestion committee for ideas that are patentable. This is the remuneration that a man receives from the company for the use of the patent in its own plant, and although the patent agreement expressly states that an invention can be used free of charge, nevertheless the policy in the past has been to make a suggestion award to the inventor.

After the personnel record is made up and signed, the new man is instructed concerning the rules of the plant, rate of pay, working hours, Union Labor Agreement, suggestion system service, the various social activities—such as the Golf Club and Employees Welfare Association—and is then sent to the safety engineer.

Assuming that the applicant is passed successfully, he is sent back to the personnel office with an O.K. by the safety engineer and is given a blue slip, which shows his name, date effective, job that he is going on, rate, hours, whether new or rehired and the approval. He is also given a card of introduction to the foreman, giving his name and card number and telling the foreman what job he is sent in for. He is next sent to the time office where a time card is issued and a number assigned to him. The clock room attendant shows him how to ring the card and tells him the importance of keeping his address on his time card at all times.

Records

A folder is compiled containing the personnel record, patent agreement, blue slip, the service record card and any other information concerning the man. This is maintained in what is called the live file.

Service Record

The service record card is a very important record and on this card is recorded all transfers, terminations, etc. Speaking of transfers, a large part of personnel work is in the transferring of men from one job to another. The plan of seniority setup has always been followed. By this is meant that other things being equal, the man who has been working in a department the longest time, would be entitled to a promotion.

Service Pins

A service pin record is also kept by which we keep the issue of service pins up to date. Service pins are issued for service of five years and at five-year intervals thereafter. The 5, 10 and 15-year pins are yellow gold. the 20-year pins white gold, the 25-year pin has one diamond, and so on,

Statistical Records

Statistical records are also kept. These include additions to and changes in the payroll and also a record of termination and the reason therefor. The termination blank is filled out for a man when he leaves the employ of the company and shows the reason therefor. It is signed by the foreman and by the personnel director after the man has been personally interviewed. It is hard to get into this organization, and it is hard to get out. No foreman, or department head, has the right to dismiss an employee from the service of the company. He can suspend an employee and send him to the personnel director. A very thorough investigation is made of the causes for this dismissal, and it requires the authority of the management, the foreman and the personnel director before the paymaster will pay off a discharged employee.

Labor turnover reports are maintained which give a picture of what is going on in each department in the plant.

Suggestion Committee

The suggestion committee, which meets every week, is another very important part of personnel work. The suggestions are deposited in the boxes at the entrance of the plant and collected every Monday. These are read over and assigned to the various members of the suggestion committee for investigation. A copy is made of each suggestion and is kept in files for a follow-up. The investigators go out into the plant, interview the suggestors personally, talk to the foremen of the departments, find out all there is to know about the merits of the suggestions, and tender their reports to the committee. If a suggestion is to be dropped from the list, the man is told why and it is explained to him personally. A letter is also

written to his home, telling the man just what happened concerning his suggestion.

Several times it has so happened that suggestions have been turned down, yet a year or two later the idea has been used. By referring to the files, the suggestion is found and the man is remunerated accordingly. The original suggestions are returned and placed in the man's folder as part of his personnel record. It might be that a man has turned in fifty suggestions without receiving a prize for any one of them, but suggestions in his folder show that that man is interested in his work, and is trying to help the company by turning in his ideas.

The personnel department also looks out for retired employees. There are about 19 or 20 in this community on the retired list, who receive a voluntary contribution from the company.

Personal Finances

Some high pressure collection bureaus try to make a collection agency out of the personnel department. These matters are referred to the Welfare Association secretary for his attention. The company is not interested in collecting accounts and all sight drafts are returned. The company is, however, interested in the welfare of the men and will go out of its way to help them in every way to protect their rights.

The few things outlined and the responsibility of seeing that there is a man on every job in the mill as needed are regular routine. The biggest part of the work is in the personnel problems that constantly arise. Every man has his own individual problems; collectively they are the problems of the personnel department and are treated with all of the consideration possible.

An endeavor is made to know each man in the plant, to become acquainted with his ability and qualifications, study his adaptability to certain classes of work, educate him in all phases of papermaking, make his environment safer and more pleasant and to assist him in his problems both inside and outside the mill.

CHAPTER XXX

PROGRAMMING

By H. M. GREEN

The Order Department has two fundamental duties to perform. The first concerns the Sales Department and customers in assuming the responsibility of arranging for and providing prompt and correct shipment of orders.

The second concerns mill operations in that a program or schedule for machine operations of the paper machines and the converting plants must be worked up from the orders on hand. This program must be worked out in a manner to provide the most efficient operation possible.

The program and production schedule for the Camas Mill Operation is forecast and governed by our sales and operating executives and is subject, of course, to revision from time to time to take care of unforeseen conditions affecting sale and production of our various products.

The production schedule handled by the order department is the converting of orders on hand into a plan for the machine operation from week to week. This program is governed by orders which we receive from day to day.

The programming of the Camas plant is divided into three departments: the Bag Factory handling all plain and printed bag orders, the Converting Plant handling all orders for toilet tissue, paper towels and napkins, and the Main Office from which are handled orders for plain and printed wrapping paper, wrapping tissue and fruit tissue.

Bag Factory Order Department

The programming of bags will vary at times according to the amount of bags on order. The ideal set-up is to establish a weekly production figure based on past sales and forecast of future sales, maintaining this production throughout the entire year.

When business is slow, inventories will be built up on the basis of what is termed a balanced stock. Production of bags for stock is regulated in the various sizes to the ratio of sales during a period of six months or a year.

When business picks up and orders are being received in excess of the rate produced, inventories will be reduced accordingly.

Difficulty in adhering to this program lies in the fact that changing

market conditions often make it impossible to accurately forecast bag sales, which, in turn, is the basis for regulating production.

If an oversold bag condition occurs at a time when stocks are depleted, it is necessary to establish and follow a preference list for the orders as they are received.

The order department works quite closely with Bag Factory supervision in compiling bag machine programs. The order and stock situation is reviewed for the various sizes and grades and arrangements are made for the manufacture of any special grades of bags and, in general, planning production of bags needed for immediate shipment or to properly balance out stocks on hand.

Close contact is maintained with the shipping department since the order department, from the knowledge of orders on hand, production and stock, provides the shipping department with their daily schedule of shipments to be loaded.

From the weekly schedule of bag machines, the paper requirements for the entire plant are figured and arrangements made through the main office order department to have paper manufactured and available at all times to keep machines operating.

The printing department is provided with a line-up on printed bag orders and contact and follow-up is maintained to see that orders are printed and ready in time for shipping date requested. All other matters pertaining to proofs, printing copies, and cuts in connection with printed orders are referred to the order department to be taken up with proper parties for decision.

A close follow-up is maintained in all phases of bag production, finishing, printing and shipping in order to expedite shipment of orders and meet scheduled shipping dates.

For accounting purposes the order department also keeps a record of bag paper usage and stock on hand; inventory, production and shipments of finished bags; and such miscellaneous items as inventory, production, and usage of labels, cartons, printed bags, millwrapper and other supplies.

Converting Plant

Converting Plant programming is quite similar to the Bag Factory set-up in that the various machines are provided with running schedules which are dependent upon the orders on file requiring shipment from day to day.

It is customary to forecast the sale of towel and toilet tissue grades and set up a production figure to be maintained.

This production figure may vary according to changing market con-

ditions affecting the sale of the various grades as well as the order situation on other grades of wrapping tissue, which, in turn, has an effect on the amount of paper that can be produced for conversion into toilet tissue grades.

An endeavor is made to keep production at a set figure, building up large stocks of standard items during slack periods and utilizing this stock during times when orders received exceed production. Here again when an oversold condition exists close contact is maintained with our San Francisco and Portland offices to arrange for production of the various customers' orders in the proper sequence.

In programming the production of the converting plant the shipping department is given a list of shipments to be made each day and it is desirable, whenever possible, to have an order manufactured on the machine and sent on the conveyor direct to the cars for loading, rather than take merchandise from stock and then replace it a few days later. This requires constant contact with orders and machine operation to work out the most efficient schedule of operations.

Considerable attention is required in the handling of supplies such as labels, bands, empty cartons and paper stocks. Inventories on all these items must be watched and their usages anticipated so that production is not held up because of lack of any particular item.

For accounting purposes, records are kept on all paper usages and stock on hand, complete record of production, shipments and inventories of finished products, together with usage and inventory of labels, bands and empty cartons.

The napkin division is part of the Converting Plant operation and the set-up for this department is the same as that for towels and toilet tissue.

Wrapping Program

In programming of tissue machines from the main office, first consideration is given to the requirements of paper needed for the weekly operation of the converting plant and space allotted on the tissue machines to take care of this. No. 11 machine at Camas runs constantly on toilet tissue grades and as a general rule, takes care of almost all of the toilet tissue requirements. Roll toweling and napkin requirements are allotted necessary space on Nos. 1 and 2 machines. Folded towel paper requirements are obtained from West Linn Mill except for small occasional runs which are made on Camas Nos. 4 and 5 machines.

The remainder of running time on tissue machines is allotted to the various wrapping tissue orders and commitments on hand.

If there happens to be a shortage of orders it is possible to build up

our standard stock items of wrapping tissue grades or run on Los Angeles citrus for storage.

It is possible to run and store a large quantity of Los Angeles citrus paper and this is done particularly during the winter months so that the tissue machines will be available during the summer months for deciduous fruit paper.

Through the medium of being able to run either fruit paper or citrus wrap for storage, it is possible to take up machine running time during slack periods.

In programming the wrapping machines first consideration is given to the quantity of paper needed for the bag factory and space allotted on various machines.

The remainder of the time on the wrapping machines is available for the manufacture of whatever wrapping orders we happen to have. There is such a variety of sizes, basis weights and grades of wrapping paper that it is practically impossible to manufacture and carry a working stock of all grades.

As a result, when a wrapping order is received it may be necessary to hold the order for a short period, until it is possible to arrange a paper machine run of the grade covered by the order.

If an order happens to cover four or five different grades, and this is by no means unusual, it may even require several weeks before a run of each grade has been made and the order is ready for shipment. Naturally, it is desirable to give prompt service on all orders but constant attention must be given to frequency and tonnage of the various grades manufactured so that machine efficiency and production will not be unnecessarily penalized.

A close follow-up and contact is maintained with both the finishing and shipping departments. The scheduling of machine production has considerable bearing on the operations of both of these departments and the order department, having knowledge of production of the various orders, provides the finishing and shipping departments with a daily schedule of orders to be finished and shipped.

In planning the production of all machines for any particular week careful consideration is given to the demands being made on the pulp mills. The capacities of the various pulp mills are known and as far as possible the schedule is made up in such a way that no impossible demands are made of one particular unit.

As an example, there are four machines available for manufacture of kraft grades. It is a distinct disadvantage to the pulp mill to run four

machines on kraft one week and only two the following, which means a peak demand for kraft pulp one week and a light usage the following. It would be much better to arrange a schedule to run three machines on kraft both weeks.

The same is true in scheduling machines on sulphite grades. Schedules should not call for too many machines on bleached grades and the usage of bleached pulp should be held down to a figure that does not materially exceed the capacity of the bleach plant.

Production on grades requiring special pulp must be anticipated far enough in advance to allow preparation without upsetting pulp mill schedules.

The machine programs made up by the order department cover complete instructions as to the quantities and sizes of the various grades to be run. Copies of these programs provide the finishing and shipping departments with finishing, labelling and shipping specifications.

One of the most important phases of the work involved in making up these machine programs is "trim." Orders must always be made up in a manner that will allow running the maximum width on any paper machine. Occasionally there are instances where narrow trims must be run, but in a majority of cases, orders cover roll combinations that make it possible to obtain very near the maximum width of the machine. Orders are solicited from customers in such a way as to provide a satisfactory paper machine trim. Even with this trade custom, by careful work and study, it is frequently possible to rearrange roll combinations to provide a wider trim. Maximum paper machine trim varies at times according to the grade being run and condition of machine clothing as well as other operating and pulp conditions which affect the width of the web.

Importance of wide trims can be readily appreciated when one considers that a reduction in trim of 2 inches on No. 8 machine at Camas means a decrease in production of almost $2\frac{1}{2}\%$. A similar reduction applied to all machines in any one day would mean a loss in production of from 10 to 12 tons.

There are so many factors involved in setting up a program it is needless to say that a perfect one is rarely accomplished. Summarizing the foregoing, the principal points in connection with a good program are as follows:

1. Service to customer which means prompt and correct shipment of orders.
2. Efficient schedule of daily machine operations. This calls for a minimum of grade and basis weight changes and provides for long runs on machines as much as possible.

3. Balanced schedule for pulp mills. This calls for minimizing peak load demands on the kraft and sulphite mills and bleach plant. A schedule of pulp usages for the machine which averages close to maximum daily output is sought.
4. Maintaining a reasonably even flow of business through the finishing rooms and shipping department, thereby providing constant work and eliminating surges and rush periods and subsequent slack or dull periods with little or no work.
5. Wide trims for paper machines with resulting increase in production.

These are the main points given attention by the order department in handling orders and programs. Constant attention and constant follow-up of the various items is required to provide a program that will be of the most benefit to the customer and the Company.

CHAPTER XXXI

PURCHASING

By H. D. KENNEDY

The business of buying, whether it be groceries for the home, or a million dollars' worth of materials for a paper mill, should be based on the following considerations:

1. Buying the proper products and materials for the purpose intended.
2. Having these materials and supplies at the right place at the right time.
3. Purchasing at the proper prices.

These are just common sense statements, but if any of them are slighted, operating efficiency decreases and costs go up. Take the first point—what use at any price would there be for limerock unfit for the towers, inferior rosin size, chipper knives that turned out poor chips, or screens that functioned improperly.

Point two is equally as evident—tools and materials fifty miles from Camas are of no value when there is a gang of men ready to go to work. In fact, the purchase and assembling of materials and supplies usually precedes the hiring of men. If the purchasing department should allow a single major item, such as dyestuffs, chlorine, size, lime, salt cake, etc., to become exhausted the operation of the whole mill would be thrown out of balance with possibly heavy losses or even actual loss of business due to inability to meet shipping dates.

To some people point three might seem to be the most important item in purchasing,—the question of prices. Price, however, is not the primary consideration in purchasing, as an article is really expensive at any price if it is unsatisfactory and sometimes the article of highest first cost proves to be the cheapest in the long run.

Thus the function of the purchasing department, in procuring various needed items of equipment, material and supplies in proper quality and delivered as required, is an important one in promoting the continuous operation of the plant.

The buyer must make sure that his sources of supply are reliable. Shipments of materials must be uniform in quality and the supplier must have the facilities to enable him to make deliveries according to plant

requirements. Usually it is desired to keep suppliers pretty well informed as to the uses their materials and equipment are put to so that they can better understand our problems and share in the responsibility of proper performance. It may be desirable to split purchases among several companies, partly to put the business on a more competitive basis and partly to protect operations in case of failure of any one source of supply due to fire, strikes or other unforeseen circumstances.

The purchasing department must be continually on the alert for new and better sources of supply. A buyer must also keep informed as to business trends, price changes and world conditions and must be able to anticipate as far as possible price changes affected by business cycles, crop conditions, political angles, freight rates, import duties and the many other factors affecting trends in modern business.

Generally speaking, the purchasing department does not specify what materials to buy. The engineering, technical and operating departments determine what type of pump or motor is best suited for a certain use, what metals shall be specified for a job, what type lubricating oil is required for a certain machine, what pigments are required for the beaters, etc. However, the purchasing department does not consider its job finished when an item is bought and delivered. It endeavors to learn as much as possible of the uses and requirements of all materials and supplies, so that ordering can be done more intelligently and specifications properly checked with salesmen.

When material or equipment fails to perform properly, the purchasing department should be promptly notified in detail so that they can in turn take it up with the supplier. It is only by such careful checking that we can learn what companies are not supplying products uniformly up to standard. This also indicates to the supplier that careful scrutiny is given his product and assures better service and a more careful check of quality.

The purchasing department must constantly be on the alert for information regarding new products, improved equipment, price trends, etc., and to this end, contacts must continually be made with representatives of supplying companies and all information obtained must be directed to the departments interested.

The paper industry, like other large manufacturing industries, has developed standards or specifications for the purchase of its major raw materials. In some cases these are based on accepted standards of the American Society for Testing Materials, the American Engineering Standards Committee, The Federal Specifications Board, or the U. S. Bureau of Standards. In other cases they are based on specifications compiled by

the company's engineering and technical departments according to the plant's particular requirements. For example, lime is purchased with a certain calcium carbonate content and minimum of insolubles, and fuel oil must have a certain B. T. U. value and maximum percentage of basic sediment and moisture. As far as possible, these purchasing specifications are made clear and specific to properly describe the material and its performance requirements. Specifications must be carefully worked out on a strictly practical basis. If they set a standard too high or too difficult to comply with, then the cost of the material will be increased without a corresponding benefit.

In a properly conducted business, responsibility and authority must be delegated to certain divisions. This is true of purchasing as well as financing, accounting, engineering, programming and other mill departments. In some mills, in the past, everybody, from the office boy to the manager, would contact salesmen and arrange for purchase of supplies. There is too much at stake, however, to allow this practice to exist in a large plant, and the authority for purchasing must be centralized in one department. In fact, taking industry as a whole, about fifty-five cents of the manufacturer's dollar is spent for materials and supplies. This represents a large proportion of manufacturing costs, and on the careful spending of this amount largely rests the success of the business.

The purchasing department at Camas has the responsibility of spending about two and a half million dollars each year. The accompanying table may be of interest in showing where most of this money is spent and will give an idea of the large amount of materials required to keep the plant operating. For example, the amount of water used exceeds the requirements of Portland, a city of 300,000 people. Fuel consumed annually is sufficient to operate a steam locomotive day and night at 40 miles per hour for 14 years.

Camas Mill
June 19, 1840

USAGE OF VARIOUS MATERIALS DURING THE YEAR 1939-40

Wood.....	126,000,000 Board Feet	Sulphur.....	28,000,000 Pounds
Water.....	24,200,000,000 Gallons	Lime Rock (and	
Electricity.....	159,000,000 K.W. Hrs.	Dolomite)...	36,200,000 Pounds
Lubricating Oil		Salt Cake.....	11,200,000 Pounds
(Estimated...) 45,000 Gallons		Alum.....	4,200,000 Pounds
Grease (Estimated) 15,000 Pounds		Lime.....	7,100,000 Pounds
Steam.....	2,400,000,000 Pounds	Rosin Size.....	4,000,000 Pounds
Hog Fuel.....	34,000,000 Cubic Feet	Pigments.....	875,000 Pounds
Chlorine.....	9,000,000 Pounds	Dyestuffs.....	306,000 Pounds
Fuel Oil.....	130,000 Barrels		

In the plant, orders for supplies are put through on regular requisition forms. There are three of these, namely, mill requisitions, local purchase

requisitions, and foremen's requisitions. Each one of these has its separate place in carrying out the functions of the purchasing operations. Mill requisitions cover all materials purchased outside the city of Camas by Portland and San Francisco Purchasing Departments. For small items secured in town the local purchase requisition is used. The most frequently used is the foremen's requisition, or now better known as "material ticket," which covers all materials secured from the plant storeroom. In the storeroom is kept a stock of some five thousand separate items for new construction and mill maintenance. Therefore, it is important that those making out foremen's requisitions accurately and fully describe the material wanted in order to expedite the operation of the storeroom. On an average about two hundred such requisitions are handled daily, and in the course of a year about \$750,000.00 worth of tools and supplies are issued.

Receiving Material

The requisition and purchase order procedure is not complete until material or equipment has actually been received. Materials and equipment are received at the Camas mill by boat, rail freight, express, parcel post, auto truck, stage, and occasionally deliveries are made by air express to Portland, and from there by the quickest way possible to the mill. Regardless of how items arrive, they must be checked in. In other words, a receiving record must be made up by someone, giving full details of what is received in order that the Purchasing Department may check invoice billing against receipts, which is a very important factor in operations. Most of the work of checking and making up receiving records is done by a receiving clerk and storekeeper. These men are so familiar with this kind of work that they do it with speed and accuracy. Materials are placed in their respective places and receiving records are brought to the office where they are checked against orders on file and compared against shipper's invoice for price and quantities. If no errors are found and orders have been completed, a copy of the order and also the receiving record are attached to the invoice and filed, thus completing the transaction, with the exception that the original copy of the invoice is approved for payment and forwarded with a transmittal sheet to San Francisco. Also, one copy of the invoice is sent to the Portland Purchasing office for their information and one copy showing accounts charged is taken over by the accounting department.

Salvage

Someone has said that a pile of what might be considered "scrap" or obsolete material to the average person is only junk, but to the eye of the junk dealer is a "gold mine." Years ago, the mill did not have a salvage

platform, where all materials could be examined before being junked, and there is no doubt that many times material reached the "junk pile" that could have been used very well somewhere in the mill. Today, and for several years past, the mill has had a first class building, known as the salvage platform, with a "handy man" on the job every day in the week. Here, twisted iron bars are straightened out, bolts are re-threaded, others that cannot be re-threaded to the same size are cut to another size and threaded, valves are worked over, stud bolts are made up, and many other items are reclaimed that previously went to the junk pile. Workmen are being constantly urged to use salvaged material in place of new material when it will serve the purpose just as well, but at no time is a workman refused new material when he states that the job calls for new material and that he must have it. Many of the foremen are able to keep their maintenance costs to a very low figure by drawing the majority of their requirements from the salvage platform.

The storeroom stocks are kept at a proper level by adhering as closely as possible to certain predetermined maximum and minimum figures. A system of books is kept on all stock room items and when it is observed that the inventory on any item is running low, a requisition is placed with the office and the stock is again brought up to the maximum figure if it is deemed desirable to carry that amount.

Comparatively few people realize the importance of buying in the scheme of business. Every business venture must begin with buying. Money must be spent before operations start. Buildings, tools, furniture, supplies, material, labor, etc., must be purchased before manufacture of commodities begins that will finally bring returns. The same is true after operation starts—buyers must be found for these products if operation is to continue. We hear so much about production and distribution that we lose sight of the real mainspring of business—buying. Every depression is brought on by lack of buying, and when the Purchasing Agent gets busy again the dark clouds roll away and the sun of business prosperity shines again.

The money spent by a large company for labor, supplies and materials is a large factor in the community's prosperity. When it is necessary on account of lack of buyers for the mill's products, to curtail expenditures for these items, its influence is soon felt. In times of expanding business, buying can be likened to an ever-increasing circle. Greater buying makes markets for the things that are raised and produced, creates jobs for those who work, and in doing this distributes money, with which people in turn do their own buying.

The purchasing department has its responsibility to the management for results obtained in its disbursement of funds, and to the other depart-

ments for the character of service rendered. Upon it also rests the responsibility of proper and courteous contacts with outside parties in order to maintain the reputation of the company for fair dealing.

From the very nature of its functions, the purchasing department affects in some measure every department in the organization and every employee. To attain to its fullest service, it must have the complete cooperation of everyone in the mill.

The past few years have taught us as individuals that the wise and judicious spending of money is fully as difficult as earning it and that failure or success depends largely upon it. So it is with a business. Private enterprise cannot levy additional taxes to meet added expenses, as do governments. If manufacturing costs exceed income for any length of time, the business is headed for the rocks. Only by careful economy in all operations, controlled by wise and prudent management, can continued success be achieved. In this scheme of operation, well organized and properly conducted purchasing holds an important place.

CHAPTER XXXII

OFFICE ORGANIZATION

By W. J. VAN ARNAM

In a manufacturing unit, such as we have at Camas and our other mills, the primary function of the office organization is to assist the management in the smooth and efficient operation of the plant.

To accomplish this most effectively, it is divided into various sub-departments, each directly supervised by a specialist in his particular line.

While the operation of some of these departments is explained in detail in separate chapters, we will touch briefly upon all of them to indicate the part each plays in the organization as a whole.

Accounting Department

In almost any business enterprise, and specifically in a manufacturing concern, there is scarcely any transaction which does not involve the expenditure of money, or wealth. Such expenditure may not be apparent at the time the transaction occurs, but somewhere along the line money will be, or has been, spent. The performance of the various tasks by employees must be paid for in the form of wages. The use of materials in the manufacture of products or the operation of machines involves the expenditure of money for the acquisition of such materials. The mere turning of a wheel results in its wear and requires an expenditure not only for the power to turn it, but for its ultimate replacement. Even equipment which is idle a part or all of the time gradually depreciates, deteriorates or becomes obsolete and dissipates the value originally invested in it and often necessitates the expenditure of more money to replace it. Every move costs money and it is only through the judicious control of expenditures and the receipt of full value for the money spent that a business enterprise can long survive. It behooves us, therefore, to keep our executives constantly informed as to how much, where and for what, we are spending the money of our company and the department assigned to this task and given this responsibility is the Accounting Department.

Through the medium of various records and reports the Accounting Department is able to translate the multifarious transactions of the company into dollars and cents and to present this information to the executives and department heads in such manner and at such times as to

assist them in the efficient direction of the operations of the company.

Within the Accounting Department there are two branches, - one, Financial or General Accounting, which is done at our Headquarters and which comprises the calculation of and accounting for our sales, assets, liabilities, capital and net worth; and the other, Manufacturing or Cost Accounting, which involves the calculation of and accounting for the cost of operating our manufacturing divisions and determining the cost of the products made. With this latter branch we are more concerned here.

Within the limited confines of this chapter, we will not attempt to cover the Cost Accounting system in detail, but will merely outline the principal factors involved in the operation and use of the system.

Because of the wide diversity of manufacturing operations conducted at Camas, and the multitude of commodities produced, the Cost Accounting system must, of necessity, be a very detailed and comprehensive system of records and reports. It is, fundamentally, a departmental cost system in which an account is kept for each department to which is charged all raw materials, operating and repair labor, operating materials and supplies, repair materials and supplies, electric and steam power, water, other direct operating expense, indirect expense and fixed charges including depreciation, taxes, insurance and a portion of headquarters administration expense used or incurred by the department. The total operating or production cost of each department is closed out or distributed to the departments it serves on the basis of the amount of service rendered such departments and eventually the costs of the various commodities are obtained.

For purposes of accounting, the departmental cost accounts do not necessarily coincide with the departments as they actually exist from the standpoint of operating supervision, but are broken down to whatever extent is considered expedient to better portray the operating costs and assist our executives and department heads in determining the degree of efficiency at which the various departments are operating.

The following are the cost accounts in use at Camas at the present time:

Numerical Index of Accounts

Paper Mill Operation :^a

Account No.

- 100 Maintenance Jobs in Progress.
- 101 Manufacturing Burden.
- 102 General Mill Maintenance.
- 103 Technical Department Cost.
- 105 Depreciation.

Account No.

- 106 Taxes and Insurance.
- 107 Headquarters Administration.
- 108 Payroll Taxes and Insurance.
- 109 Central Technical Department.
- 131 Tramway.
- 135 Wood Flume and Conveyor.
- 136 Purchased Wood Flume and Conveyor.
- 148 Hog Fuel Bulldozer.
- 149 Hog Fuel Rake Operation.
- 150 Hog Fuel Unloading.
- 151 Refuse Hog and Conveyor Operation.
- 152 Main Hog Fuel Conveyor Operation.
- 153 Hog Fuel Conveyor Storage to Steam Plant.
- 155 Hog Fuel Inventory and Usage.
- 162 Handling Logs to Storage.
- 163 Current Boom Expense.
- 164 Sorting Logs for Sale.
- 166 Log Expense.
- 205 Raw Water.
- 206 Settled Water.
- 207 Filtered Water.
- 208 Well Water.
- 250 Steam Turbo—Electric Power.
- 255 Purchased Electric Power.
- 258 Electric Power Delivery.
- 259 Combined Electric Power.
- 260 Steam Power.
- 266 Waste Heat Boiler.
- 268 Steam Power Delivery Cost.
- 270 Lime Sludge Recovery.
- 280 Sulphite Acid Making.
- 290 Kraft Liquor Making and Recovery.
- 300 Log Inventory and Usage—Hemlock.
- 301 Log Inventory and Usage—Spruce.
- 304 Log Inventory and Usage—Yellow Fir.
- 305 Log Inventory and Usage—Cottonwood.
- 306 Log Inventory and Usage—Cedar.
- 308 Log Inventory and Usage—Red Fir.
- 315 Woodmill.
- 320 Prepared Wood Inventory and Usage—Hemlock.
- 321 Prepared Wood Inventory and Usage—Spruce.

Account No.

- 324 Prepared Wood Inventory and Usage—Yellow Fir.
- 325 Prepared Wood Inventory and Usage—Cottonwood.
- 326—Prepared Wood Inventory and Usage—Lady's Island
Cottonwood.
- 327 Prepared Wood Inventory and Usage—River Bank Cotton-
wood.
- 328 Prepared Wood Inventory and Usage—Red Fir.
- 350 Chipper Operation.
- 356 Sulphite Chip Handling.
- 357 Kraft Chip Handling.
- 359 Purchased Chip Conveyor.
- 369 Inventory and Usage of Cathlamet Chips.
- 370 Sulphite Chip Inventory and Usage.
- 371 Kraft Chip Inventory and Usage.
- 400 Groundwood Production.
- 401 Sulphite Cooking and Screening.
- 402 Kraft Cooking and Screening.
- 403 Bleach Plant Operation.
- 404 Bleached Sulphite Production.
- 405 Bleached Kraft Production.
- 406 Bleach Liquor Cost for Beater Bleaching.
- 409 Mixed Screenings Production.
- 410 Pulp Lapping.
- 430 Pulp Piling—N. O. S.
- 441 Reclaiming Lapped Sulphite.
- 442 Reclaiming Lapped Kraft.
- 444 Reclaiming Lapped Bleached Sulphite.
- 445 Reclaiming Lapped Bleached Kraft.
- 449 Reclaiming Lapped Mixed Screenings.
- 460 Groundwood Pulp Inventory and Usage.
- 461 Sulphite Pulp Inventory and Usage.
- 462 Kraft Pulp Inventory and Usage.
- 464 Bleached Sulphite Pulp Inventory and Usage.
- 465 Bleached Kraft Pulp Inventory and Usage.
- 466 Bleached Soda Pulp Inventory and Usage.
- 469 Mixed Screenings Inventory and Usage.
- 481 Pulp Pressing and Baling.
- 481A Pulp Pressing and Baling—Kamyr Product.
- 499 Waste and Rejected Paper Inventory and Usage.
- 591 Core Paper Inventory and Usage.
- 592 Sulphite Mill Wrapper Inventory and Usage.

Account No.

- 597 Waxed Mill Wrapper Inventory and Usage.
- 598 Kraft Mill Wrapper Inventory and Usage.
- 599 Laminated Mill Wrapper Inventory and Usage.
- 600 General Beater Maintenance.
- 601 Beating and Mixing—No. 1 Machine
- 602 Beating and Mixing—No. 2 Machine
- 603 Beating and Mixing—No. 3 Machine
- 604 Beating and Mixing—No. 4 Machine
- 605 Beating and Mixing—No. 5 Machine
- 606 Beating and Mixing—No. 6 Machine
- 607 Beating and Mixing—No. 7 Machine
- 608 Beating and Mixing—No. 8 Machine
- 609 Beating and Mixing—No. 9 Machine
- 610 Beating and Mixing—No. 10 Machine
- 611 Beating and Mixing—No. 11 Machine
- 612 Beating and Mixing—No. 12 Machine
- 701 Jordaning—No. 1 Machine.
- 702 Jordaning—No. 2 Machine.
- 703 Jordaning—No. 3 Machine.
- 704 Jordaning—No. 4 Machine.
- 705 Jordaning—No. 5 Machine.
- 706 Jordaning—No. 6 Machine.
- 707 Jordaning—No. 7 Machine.
- 708 Jordaning—No. 8 Machine.
- 709 Jordaning—No. 9 Machine.
- 710 Jordaning—No. 10 Machine.
- 711 Jordaning—No. 11 Machine.
- 712 Jordaning—No. 12 Machine.
- 800 General Paper Mill Maintenance.
- 801 No. 1 Paper Machine.
- 802 No. 2 Paper Machine.
- 803 No. 3 Paper Machine.
- 804 No. 4 Paper Machine.
- 805 No. 5 Paper Machine.
- 806 No. 6 Paper Machine.
- 807 No. 7 Paper Machine.
- 808 No. 8 Paper Machine.
- 809 No. 9 Paper Machine.
- 810 No. 10 Paper Machine.
- 811 No. 11 Paper Machine.
- 812 No. 12 Paper Machine.

Account No.

- 814 Kamyr Machine.
- 820 Supercalender.
- 821 Creping.
- 822 Laminating.
- 822A Powell River Laminating.
- 829 Core Making.
- 830 Finishing Room Rewinders.
- 901 No. 1 Finishing Room Maintenance and Expense.
- 902 No. 2 Finishing Room Maintenance and Expense.
- 903 Counter Roll Finishing Room Maintenance and Expense.
- 904 General Finishing Rooms Maintenance and Expense.
- 905 Finishing Materials.
- 906 Finishing Labor.
- 970 Automatic Trucks Maintenance.
- 971 Fork Trucks.
- 972 Wet Room Automatic Truck.
- 980 Warehouse and Shipping—General.
- 981 Warehouse and Shipping—No. 1 and Counter Roll Finishing Rooms.
- 982 Warehouse and Shipping—No. 2 Finishing Room.
- 984 Warehouse and Shipping—Dock.
- 990 Warehouse and Shipping—Bag Factory.
- 991 Warehouse and Shipping—Printing Department.
- 992 Warehouse and Shipping—Converting Plant.
- 993 Warehouse and Shipping—Summary.
- 999 Real Estate Operation.

Grades:

Account No.

- 1200 Groundwood Paper Specialties.
- 1430 M. F. Kraft Wrapping.
- 1440 M. F. and M. G. Kraft Bag Paper.
- 1441 Kraft Cement Bag Paper.
- 1450 M. F. Kraft Converting.
- 1460 M. G. Kraft Wrapping.
- 1480 M. G. Kraft Converting.
- 1500 Bleached Kraft.
- 1610 Unbleached Sulphite Butcher.
- 1621 Crown Envelope Manila.
- 1623 Other Sulphite Manilas.
- 1625 Cartridge Manila.

Account No.

- 1630 M. F. Sulphite Wrapping.
- 1636 Mill Wrap.
- 1637 Core Paper.
- 1640 M. F. and M. G. Sulphite Bag Paper.
- 1650 M. F. and M. G. Sulphite Converting.
- 1657 Creped Fruit Box Liner Stock.
- 1659 Uncreped Fruit Box Liner Stock.
- 1660 M. G. Sulphite Wrapping.
- 1700 Miscellaneous Bleached Sulphite.
- 1710 Bleached Meat Wraps.
- 1720 Opaque Bread Wrap.
- 1900 Jumbo Toweling.
- 2000 Fruit Tissue.
- 2011 Sanford Citrus.
- 2020 Harlingen Citrus.
- 2021 Camas L. A. Citrus.
- 2110 Toilet Tissue.
- 2130 Napkin Stock.
- 2140 Waxing Tissue.
- 2170 Unbleached Wrapping Tissue.
- 2190 Bleached Wrapping Tissue.
- 3126 Bleached Kraft—Machine Dried Pulp.
- 3136 Unbleached Sulphite—Machine Dried Pulp.
- 3146 Bleached Sulphite—Machine Dried Pulp.

Unfinished Grade Cost Accounts:

Account No.

- 01200 Groundwood Paper Specialties.
- 01430 M. F. Kraft Wrapping.
- 01440 M. F. and M. G. Kraft Bag Paper.
- 01441 Kraft Cement Bag Paper.
- 01450 M. F. Kraft Converting.
- 01460 M. G. Kraft Wrapping.
- 01480 M. G. Kraft Converting.
- 01500 Bleached Kraft.
- 01610 Unbleached Sulphite Butcher.
- 01621 Crown Envelope Manila.
- 01623 Other Sulphite Manilas.
- 01625 Cartridge Manila.
- 01630 M. F. Sulphite Wrapping.
- 01640 M. F. and M. G. Sulphite Bag Paper.

Account No.

01650	M. F. and M. G. Sulphite Converting.
01657	Creped Fruit Box Liner Stock.
01659	Uncreped Fruit Box Liner Stock.
01660	M. G. Sulphite Wrapping.
01700	Miscellaneous Bleached Sulphite.
01710	Bleached Meat Wraps.
01720	Opaque Bread Wrap.
01900	Jumbo Toweling.
02000	Fruit Tissue—Domestic Sheets.
02010	Fruit Tissue—Domestic Jumbos.
02080	Fruit Tissue—Export Sheets.
02090	Fruit Tissue—Export Jumbos.
02011	Sanford Citrus.
02020	Harlingen Citrus.
02021	Camas L. A. Citrus.
02110	Toilet Tissue.
02130	Napkin Stock.
02140	Waxing Tissue.
02160	Unbleached Wrapping Tissue—Jumbos.
02170	Unbleached Wrapping Tissue—Sheets and Counter Rolls.
02180	Bleached Wrapping Tissue—Jumbos.
02190	Bleached Wrapping Tissue—Sheets and Counter Rolls.
03116	Unbleached Kraft—Machine Dried Pulp.
03126	Bleached Kraft—Machine Dried Pulp.
03136	Unbleached Sulphite—Machine Dried Pulp.
03146	Bleached Sulphite—Machine Dried Pulp.
03150	Groundwood Pulp.
03160	Screenings Pulp.
03200	Laminated Paper.
03250	Powell River Laminated Paper.
03500	Tissue Excelsior.

Finished Grade Cost Accounts:

Account No.

11000	Newsprint Paper.
11100	Groundwood Paper—News Grade.
11200	Groundwood Paper Specialties.
11430	M. F. Kraft Wrapping.
11440	M. F. and M. G. Kraft Bag Paper.
11441	Kraft Cement Bag Paper.
11450	M. F. Kraft Converting.

Account No.

- 11460 M. G. Kraft Wrapping.
- 11480 M. G. Kraft Converting.
- 11500 Bleached Kraft.
- 11610 Unbleached Sulphite Butcher.
- 11621 Crown Envelope Manila.
- 11623 Other Sulphite Manilas.
- 11625 Cartridge Manila.
- 11630 M. F. Sulphite Wrapping.
- 11639 Lebanon Add-An-Ad Wrapping.
- 11640 M. F. and M. G. Sulphite Bag Paper.
- 11650 M. F. and M. G. Sulphite Converting.
- 11657 Creped Fruit Box Liners.
- 11659 Uncreped Fruit Box Liners.
- 11660 M. G. Sulphite Wrapping.
- 11700 Miscellaneous Bleached Sulphite.
- 11710 Bleached Meat Wraps.
- 11720 Opaque Bread Wrap.
- 11900 Jumbo Toweling.
- 12000 Fruit Tissue—Domestic Sheets.
- 12010 Fruit Tissue—Domestic Jumbos.
- 12080 Fruit Tissue—Export Sheets.
- 12090 Fruit Tissue—Export Jumbos.
- 12011 Sanford Citrus.
- 12020 Harlingen Citrus.
- 12021 Camas L. A. Citrus.
- 12110 Toilet Tissue.
- 12130 Napkin Stock.
- 12140 Waxing Tissue.
- 12160 Unbleached Wrapping Tissue—Jumbos.
- 12170 Unbleached Wrapping Tissue—Sheets and Counter Rolls.
- 12180 Bleached Wrapping Tissue—Jumbos.
- 12190 Bleached Wrapping Tissue—Sheets and Counter Rolls.
- 13116 Unbleached Kraft—Machine Dried Pulp.
- 13136 Unbleached Sulphite—Machine Dried Pulp.
- 13146 Bleached Sulphite—Machine Dried Pulp.
- 13150 Groundwood Pulp.
- 13160 Screenings Pulp.
- 13200 Laminated Paper.
- 13250 Powell River Laminated Paper.
- 13310 Fruit (Pear) Pads.
- 13500 Tissue Excelsior.

Bag Factory

Operating Cost Accounts:

Account No.

- 4001 Bag Factory Indirect Cost.
- 4011 Bag Machine Line—Parrish.
- 4012 Bag Machine Line—Potdevin S. O. and Duvall.
- 4014 Bag Machine Line—Potdevin (Special).
- 4015 Bag Machine Line—Weber.
- 4016 Bag Machine Line—Fruit Pads (Pear).
- 4031 Aniline Press Cost.
- 4041 Bale Finishing Cost.
- 4051 Carton Finishing Cost.

Bag Factory Product Cost Accounts:

Account No.

- 4100 Paper Shipping Sacks.
- 4200 Grocery Bags.
- 4300 Millinery Bags.
- 4400 Notion Bags.
- 4500 Banana Bags.
- 4600 Garment Bags.
- 4700 Shopping Bags.
- 4800 Arsenate of Lead Bags.
- 4900 Poultry Bags.
- 5000 Standard Sacks.
- 5100 Bread Bags (Not Grocery Sizes).
- 5200 Raisin Bags.
- 5300 Confectionery Bags.
- 5400 Carton Liners.
- 5900 Miscellaneous Bags.
- 5990 Sample Bags.
- 5991 Fruit Pads (Pear).

Converting Plant

Operating Cost Accounts:

Account No.

- 6001 Converting Plant Indirect Costs.
- 6002 Converting Plant Core Making.
- 6003 Interfold Towel Machines.
- 6004 Roll Rewinders.
- 6005 Singlefold Toilet Machines.
- 6006 Doublefold Toilet Machines.

- 6008 Roll Wrapping Machine.
6009 Case Sealing Machines.

Converted Product Cost Accounts:

Account No.

- 3430—Waxfibre Pack—Purchased.
3444 Waxed Lunch Rolls—Manufactured.
6100 Interfold Towels—Manufactured.
6110 Interfold Towels—Purchased.
6200 Roll Towels—Manufactured.
6210 Roll Towels—Purchased.
6300 Household Towels—Manufactured.
6310 Household Towels—Purchased.
6400 Towlsaver—Manufactured.
6410 Towlsaver—Purchased.
6500 Steiner Towels—Manufactured.
6510 Steiner Towels—Purchased.
7100 Singlefold Toilet—Manufactured.
7110 Singlefold Toilet—Purchased.
7200 Doublefold Toilet—Manufactured.
7210 Doublefold Toilet—Purchased.
7300 Recessed Folded Tissue—Manufactured.
7310 Recessed Folded Tissue—Purchased.
7400 Roll Toilet—Manufactured.
7410 Roll Toilet—Purchased.
7510 Comfort Toilet—Manufactured.
7540 Zee Toilet—Manufactured.

Napkin Division

Operating Cost Account:

Account No.

- 6012 Napkin Machines Cost.

Napkin Product Cost Accounts:

Account No.

- 8100 Plain Tissue Napkins.
8200 Flat Bulk Napkins—Manufactured.
8210 Flat Bulk Napkins—Purchased.
8300 Folded Bulk Napkins—Manufactured.
8310 Folded Bulk Napkins—Purchased.
8400 Sputum Papers—Manufactured.
8500 Package Napkins—Manufactured.

Printing Department

Operating Cost Accounts:

Account No.

- 939 Printing Department Indirect Costs.
- 940 Composing Room.
- 942 Rubber Plate Making.
- 943 Ruling Machine.
- 944 Bag Printing Presses.
- 945 Platen Printing Presses.
- 946 Flat Printing Presses Nos. 4, 5, 10, 15 and 16.
- 947 Roll Printing Presses Nos. 9 and 18.
- 948 Stripe Printing Press No. 17.
- 949 Fruit Printing Presses Nos. 1, 2, 3 and 4.
- 950 Rewinder No. 19.

Printing Department Product Cost Accounts:

Account No.

- 951 Bag Printing Cost.
- 952 Bag Machine Printing Cost.
- 953 Job Printing Cost.
- 954 Fruit Printing Cost.
- 956 Wrapping Printing Cost.

As will be noticed from the foregoing, the finished products are costed in group accounts in which all products of a similar nature are combined. For example, M. F. Sulphite Wrapping Paper Grade Cost Account includes the cost of all grades, basis weights and colors of M. F. Sulphite Wrapping. This is sufficiently detailed for many purposes of cost analysis and comparison; however, to enable our Sales Department to establish prices and formulate sales policy, it is necessary that they be informed of the cost of every product we make.

Inasmuch as we manufacture some five thousand different products at Camas, it is obvious that it would be highly impracticable to carry a separate cost account to be calculated monthly, for each product. We therefore resort to the use of standard costs in determining the cost of each product. Based upon the experience of the past and what we are able to expect in the immediate future, we determine the standard cost of the principal cost components of our finished products. In the case of a grade of paper these components are the cost of pulp, miscellaneous furnish such as alum, size, etc., the cost of anilines used in coloring the furnish, beating, jordaning, paper machine conversion and finishing.

From our statistical records, wherein complete operating details are kept of every run of every product made, we are able to secure among other things, the quantities of pulp, miscellaneous furnish and anilines used per ton of every product made, along with the beating time, the amount of electric power used in jordaning, the product per hour off the paper machine and the standard usage of finishing materials in finishing the various forms of rolls and sheets and the units finished per labor hour. To these standard quantities we apply the standard cost of each of these components of the finished product as determined from the cost accounts and arrive at a standard cost of every product. These standards are revised continually or whenever it is determined that there have been sufficient changes in operations or component costs to materially affect the cost of the commodity.

Another service for which the cost accounting system is designed and one which is of utmost importance to our operating and sales executives is the computation of the estimated costs of new products, or the resultant cost due to changes in manufacture or materials used in regular products. Before the Sales Department will commit itself to the sale of a new product or changes in an old one, they first must know whether it can be manufactured as specified and if so, at what cost. The Technical Department, in collaboration with the operating heads, determines the manufacturing requirements and specifications of the proposed product. If these are found to be practicable from an operating standpoint, the Accounting Department then, from the technical and operating data submitted, estimates the cost at which the product can be made. This information is then conveyed to the Operating and Sales Departments where it is used to guide them in deciding whether or not the product will be offered for sale. If they decide to manufacture the product, upon completion of its manufacture, a Product Cost is made. This represents the actual cost of the product for comparison with the estimated cost and includes the costs resulting from any changes from the original estimate which might have been made in operations and materials.

Our industry is continually advancing. Improvements in machinery and processes are being made all the time. So that we may keep abreast of this advance and maintain operating efficiency, our plant must undergo a steady revision in the operating processes. This entails the installation of new equipment and the rebuilding of old. To assist in determining the desirability of making these changes in operations, the Cost Accounting Department is called upon to calculate just what effect these changes will have on the manufacturing costs. By assembling the information submitted by the operating, engineering and technical departments and interpreting it into dollars and cents, the resultant costs to be derived

from the operating changes can be determined. Then, if they are found advantageous, they are made.

As an accounting requirement so that we may know the amount invested in Capital Assets, represented by plant, buildings and equipment, and to comply with the regulations of the Internal Revenue Department in determining the depreciation allowable for purposes of Income Tax, we must keep the records of the cost of all equipment installed in or removed from our plant. The costs of all labor, materials and services for each construction or maintenance job are accumulated in separate accounts. The amounts accumulated in maintenance jobs are closed out monthly as maintenance expense to the departmental cost accounts representing the departments in which the maintenance work is done.

The cost of capital jobs covering the installation or replacement of buildings or equipment is held in the mill office construction accounts until the job has been completed and all items entered to the account. A detailed statement of the cost of the job is then made up and forwarded to the Headquarters Accounting Department where it is entered in the plant records.

To keep the management constantly in touch with the various components of operating cost of a department, or in some cases, a mechanical unit, so that they may measure its efficiency both from the standpoint of mechanical operation and supervision, the information contained in the departmental cost statements is not only used as it appears on the statements, but it is rearranged and restated in separate reports to more clearly bring out certain pertinent information. This phase of the use of cost accounting information is termed Cost Control and it plays a considerable part in contributing to the efficient management of our company.

Timekeeping Department:

This department is responsible for the calculation and preparation of the wage payroll and the issuance of payroll checks. To do this they must compute the time worked by each employee, apply the correct rate of pay for such work and arrive at the total amount due each employee for each pay period. They must also determine the amount of Workmen's Compensation premiums payable to the State, the amount of the company's and employees' contribution to the Federal Old Age Benefit Plan and the company's contribution to the State and Federal Unemployment Insurance Fund. In addition to the calculation of the payroll they distribute the wages paid to the various departmental cost accounts.

In order to determine the amount of time worked by an employee, it is required that each employee punch a time card. This card shows the

time he began and the time he quit work and from it the timekeepers compute the total hours worked. As a supplement to this record each foreman turns in a Daily Labor Segregation which shows the hours worked by each employee in his department and the type of work performed. This report is checked against the time shown on the time cards to see that they agree and from it the Time Office is able to apply the proper rates of pay for the various jobs as provided for in the wage schedule and to distribute the amount of wages paid to the various departments or operations of the mill. This distribution forms a part of the accounting system which enables our executives and department heads to keep informed of the labor cost to operate each department and ultimately enables us to determine the cost of every product manufactured.

With the advent of the Social Security Laws, a new responsibility and function was required of the Timekeeping Department. Under the law it is required that a complete record of each employee's earnings be retained and from it quarterly reports are made to the Internal Revenue Department and to the State Unemployment Compensation Commission. These reports show the name, social security registration number and total amount earned during the three preceding months for each employee and serve as a basis for the State Unemployment Compensation Commission to calculate the amount of compensation which might be paid to one who has become unemployed and for the Internal Revenue Department to determine the amount of Old Age Benefit due employees over the age of 65 years, who have retired.

Obviously, the records of the Timekeeping Department must be very accurate to insure that the employees are paid the correct amounts due them; that there be no error in the earnings reported to the State and Federal Governments with a consequent error in the amount of Unemployment Compensation or Old Age Benefit an employee or former employee might receive and to obtain correct information as to the departmental operating costs and costs of commodities produced.

There are other duties performed by the Time Office which, while they do not pertain directly to the keeping of time and computing of payroll, are of equal importance. These include the compilation of special reports concerning labor and employees, both for our own use and that of various governmental agencies; assistance to the Personnel Manager in matters pertaining to employment and personnel records and a general cooperative service to the other employees of the organization.

Stores Department:

Inasmuch as the lack of any required raw material, operating supply

or repair material might cause serious and costly delay in the operation of the plant with a consequent loss of production and revenue, the responsibility of maintaining adequate stocks is vested in a separate department. This department is known as the Stores Department and its primary function is to secure and keep on hand a sufficient quantity of all necessary supplies. To assist in this function it is necessary that complete records be maintained of the stocks on hand of all materials used in the operating, maintenance and manufacturing processes. These records are the Stock Ledgers, in which a separate account is kept for every type of material used. To these accounts are posted the quantities and costs of all materials received and issued. As stocks of regular supplies fall to a predetermined minimum they are replenished. This is done by the issuance of a request for purchase drawn on our Purchasing Department in Portland, and in the case of certain materials, in San Francisco, who in turn arrange for the purchase and delivery of the required materials.

Special materials, such as special ingredients for our manufactured products or special equipment for installation in the manufacturing departments, or special services are ordered upon specifications supplied by the operating, technical or engineering departments, as the case may be.

The stocks of general supplies of a nature which are conveniently stored within an enclosed area, are kept in the store room and are issued only upon the submission of a material ticket signed by a foreman or someone authorized to draw material from the Mill Store.

Materials of such bulk or quantity or materials which must of necessity or convenience be stored outside of the Mill Store, are under the direct control and responsibility of the foremen in whose departments they are stored or used. In some cases the usage of these materials is determined by the taking of physical inventories each month, while in others the quantities are reported as they are used. Of course, actual physical count or measurement of all items is taken at least once a year, at which time the quantities and values in the stock ledgers are brought into agreement with the actual amounts and values on hand.

In addition to the information describing the quantities and kinds of materials issued, contained in the material tickets, there is also shown the departments or processes in which the material is to be used. From this information, the stock ledger account is not only credited with the amount of material used, but the proper department or process is charged. As in the case of the Timekeeping Department, where the cost of labor is distributed to the cost accounts, in the Stores Department the cost of material used in each department or process is distributed.

Mill Order Department:

Upon receipt of customers' orders at our various Sales Offices, they are turned over to the Order Departments, in our San Francisco or Portland offices, depending upon the territories in which the customers are situated. There the information is transferred to uniform order forms. These forms contain the name of the customer, destination of the shipment, routing, prices, terms, required shipping date and a complete description of the amounts and commodities ordered. They are then transmitted to the Order Department of the mill from which shipment is to be made. It is the function of the mill Order Department to either arrange for shipment from stock if the articles are stock items, or if not, to schedule their manufacture in compliance with the description contained in the order.

Stock records of all manufactured articles are kept in each of the Mill Order Departments. These records show the quantities of the various grades of paper, bags, toilet tissue, towels, napkins or other manufactured products on hand, and are used not only to assist in the programming of machines for the manufacture of products, but as a basis for determining the values of the finished products on hand for accounting purposes.

Billing Department:

As orders are filled and goods are shipped it is, of course, necessary that bills of lading, invoices and other documents be prepared covering such shipments. This part of the work is performed by the Billing Department. Original weight sheets and other reports in pencil form, fully describing the quantities and kinds of products shipped, along with information identifying such shipments with the customers' orders, are turned into the Billing Department by the Shipping Department, and from these the bills of lading and invoices are typed. Needless to say, it is highly important that there be no delay in the preparation of these papers as the shipment cannot go forward until bills of lading have been submitted to the carriers, and it is of considerable convenience to the customers to receive their invoices as promptly as possible.

Stenographic Department:

The Stenographic Department might be termed the Service Department of the office. Its many duties include the typing of letters, memorandums and reports, the distribution of incoming mail and the preparation of outgoing mail, the filing of correspondence, reports and records, the transmission, receipt and delivery of messages by teletype, the operation of the telephone switchboard, the checking by means of mechanical calculators, the arithmetical accuracy of all reports containing figures, the calculation and preparation of certain routine reports, the operation of the

mimeograph and ditto reproducing machines and the maintaining of adequate stocks of office stationery and supplies.

The speedy and efficient operation of this department contributes largely in assisting the executives and others of the organization in transmitting their instructions, orders, ideas and information quickly and in a form requiring a minimum of effort to read and understand.

CHAPTER XXXIII

CONVEYING AND HANDLING MATERIALS

By I. C. SHOTWELL

This chapter outlines conveying and handling of materials in the Camas plant with notes on types of equipment used. No attempt will be made to cover overhead cranes, gas or electric trucks, locomotives and similar equipment. Discussion will deal mostly with the handling of raw materials.

The subject will be treated under two headings, Conveyors and Pumps, covering respectively the handling of bulk solid and liquid materials.

CONVEYORS

The eight types most commonly used in the plant are as follows:

1. Log dog chain conveyor.
2. Muck bar chain conveyor.
3. Box or refuse chain conveyor.
4. Flume wood conveyor.
5. Double chain flight conveyor.
6. Belt conveyors.
7. Bucket elevators.
8. Screw or ribbon conveyors.

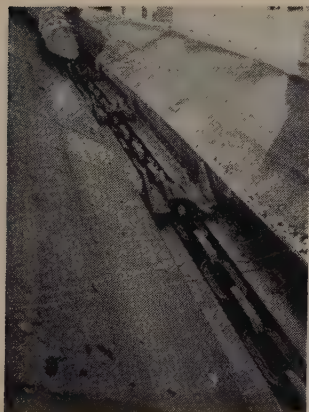


Fig. 157
Log Dog
Chain Conveyor

As can be seen from the large number of different types used, there are many factors to be considered in the selection of a conveyor for a particular job.

Log Dog Chain Conveyor

This conveyor consists of a heavy steel chain with cast steel toothed dogs attached about every 10 feet. The chain runs in a metal-lined V-shaped trough, and carries the logs from the river water level to the log deck in the wood mill. This is a slow-moving conveyor and requires considerable power.

Muck Bar Chain Conveyor

The bars or flights of this conveyor are dragged along the flat metal bottom of a trough by a large steel chain in the center. The sloping walls of the trough, also metal lined, keep the material in contact with the flights. These conveyors will stand a lot of abuse and will work under very severe conditions. In the Camas plant they are used for handling block wood and hog fuel. One of these conveyors will handle about 40,000 board feet of block wood per hour, or sufficient material, if converted into lumber, to build five modern six-room houses.



Fig. 158
Muck Bar Chain Conveyor
Feeding Wood to Chippers

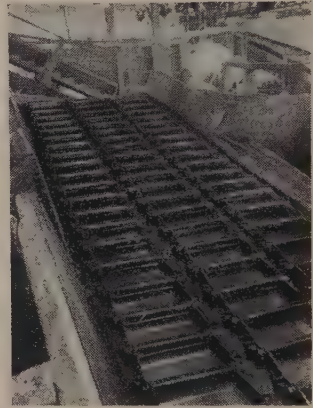


Fig. 159
Box Chain
Conveyor

Box or Refuse Chain Conveyor

The box chain is so named because the links of the chain are in the form of rectangles, the side bars and cross bars being cast integral. The links are from 6 to 18 inches wide and from 5 to 8 inches long. They are joined by a steel pin which goes through the cross bar. The size of the chain is limited by its construction so when more capacity is required than one chain can handle, two or three are placed side by side in the same trough and with common driving and idle sprockets.

This type is not suited for long conveyors or very heavy service, being limited by the strength of the material used. They will operate on inclines up to about 45° at reasonably low speeds. Abrasive materials should not be handled due to excessive wear on the chain and bottom. The first cost of these conveyors is low but they require considerable attention and upkeep. A number of these chains are used in the wood mill and chipper plant for handling block wood and refuse.

Flume Wood Conveyors

The conveying element in this case is water. All that is required to handle wood by this method is a trough or flume from the wood supply to the point of delivery, and a source of water supply. The wood is floated along the flume in the stream of water. At the Camas plant, due to the shortage of water at certain seasons, it is profitable to pump the water from the discharge end of the flume back to the upper end to be used over and over, adding only enough to make up for losses due to leakage.



Fig. 160
Flume Conveyor

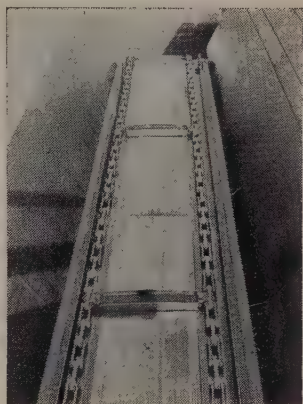


Fig. 161
Convêyor to Disc Barkers

Double Chain Flight Conveyor

Two parallel chains with cross bars or flights between them form the conveying element in this type. The bottom of the trough is flat and the bars form squares or boxes which give it an enormous pulling power. They will operate on inclines up to 45° and at linear speeds up to 150 feet per minute. They are suitable for either fine or lumpy material but not for hard or abrasive material. This type of conveyor is used in the wood hopper at the chipper plant. Wood is dumped into the hopper by the wood flume and the hopper serves as an accumulator to provide a constant supply of wood for the chippers when the discharge from the flume is irregular. At times when the hopper is full the conveyor is required to move tons of wood up the incline to discharge into the chipper plant. Another example of this type is the sulphur conveyor at the acid plant.

Belt Conveyors

The belt conveyor is an endless rubber covered belt carried on troughing idler rolls and having large end pulleys. Usually the drive is connected

to the pulley at the discharge end. Belt conveyors are best suited for long horizontal or slightly inclined runs and should not be used on *inclines* over 25° , as the material will tend to roll or slide back down the belt. Their principal uses in the Camas plant are for handling chips, hog fuel, sulphur and salt cake. Due to their high speed of approximately 800 feet per minute they will handle a large quantity of material with a small power consumption, and are noted for their low installation and maintenance costs.



Fig. 162 Belt Conveyer to Chip Bins

Bucket Elevators

The centrifugal discharge bucket elevator consists of a rubber covered belt running over large pulleys at the top and bottom. The steel buckets are round bottomed, V-shaped troughs and are attached to the belt at intervals of 2 to 8 feet. The material is delivered into a boot or pit, is scooped up by buckets, elevated, and discharged or thrown from buckets by centrifugal force as the bucket passes over the top pulley. The elevator

is completely enclosed in a steel housing. The discharge chute usually leads to a conveyor for distribution. The bucket elevator is an economical conveyor for handling chips or other fine material but is not practical for coarse or lumpy material. Speeds up to about 500 feet per minute are used and large quantities of chips can be handled at a low power cost. However this equipment requires quite an amount of attention to keep it in condition.

Screw or Ribbon Conveyors

In this type a shaft with a spiral fin or blade is supported in a round bottomed trough by bearings spaced every few feet. The shaft is driven from one end and as it rotates the material is pushed along the bottom of the trough and usually is discharged through holes in the bottom. A distinct advantage of this conveyor is its ability to thoroughly mix materials. This fact is made use of in our bleach plant where bleach liquor is mixed with the stock. A screw conveyor in an open trough can be used on a slight incline not to exceed 10° . However, if the screw is encased in a tube and a suitable device placed at the bottom to feed the material into the screw, it will work on any angle up to the vertical. An example of this may be seen in the bleaching cells. This type of conveyor requires a relatively small amount of space and can be completely enclosed to keep out foreign matter and keep the material clean.

PUMPS

In terms of number of units in use and quantity of material handled, pumps far outrank all other classes of conveyors. The main part of our discussion will concern:

1. Kinds of pumps and their uses.
2. Pump design.
3. Pump troubles.

Kinds of Pumps and Their Uses

In the Camas mill there are approximately 500 pumps of many different types designed to operate under a wide variety of conditions. The principal types are listed in the following.

Reciprocating Pump

The plungers or pistons in this pump are moved back and forth in an enclosed space drawing in fluid through one valve or port and expelling it through another. The force is applied to the plunger, either by direct connection to a steam cylinder, or by a connecting rod from a crank shaft similar to that of an automobile engine. The advantages of the reciprocating type pump are:

1. It will operate against any head or back pressure without loss of capacity.

2. Quantity is directly proportional to speed.

3. Efficiency is nearly uniform through a wide range of conditions.

They are also noted for their ability to handle comparatively large objects, such as rags, wire and sticks of wood which may accidentally get into the stock system. The principal uses of the reciprocating pump at Camas are to handle stock, water and condensate.

Nash Vacuum Pump

This pump consists of a rotor, similar to the paddle wheel on a stern wheel boat, and an elliptical case which fits the wheel closely at two points on its circumference. The case must be partly filled with water before the pump will operate. Starting at a point near the suction port, the chamber or space between the vanes of the rotor is full of water. As the vanes are

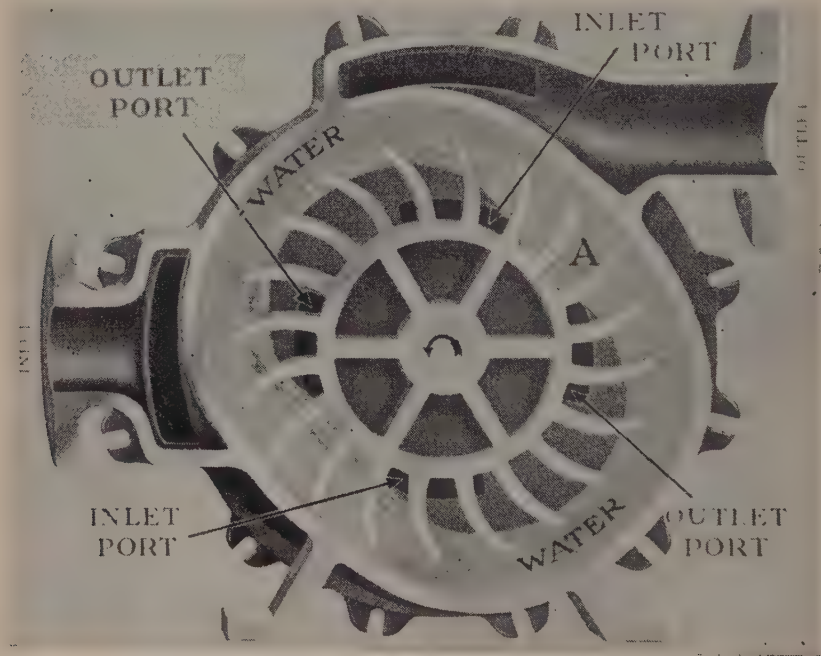


Fig. 163 Cross Section of Nash Hytor Vacuum Pump

rotated the elliptical casing permits the water to be thrown out by centrifugal force and air is drawn in. After the inlet ports are passed, the water is forced back into the rotor by the casing, compressing the air which is

trapped in the rotor. When the rotor spaces reach the outlet ports, the air under pressure is expelled into the discharge pipe by the water re-entering the rotor spaces. This action takes place twice in each revolution of the wheel, and as there are many vanes in the wheel it becomes a smooth continuous process. In this manner it is quite common for a Nash vacuum pump to handle 100 gallons or more of water and 1000 to 1800 cubic feet of air per minute. These pumps are used throughout the mill for extracting water from stock in washing and thickening pulp and on the paper machines.

The Centrifugal Pump

This is the type of pump most generally used in the Camas plant. In construction this pump somewhat resembles a fan. It consists of one or

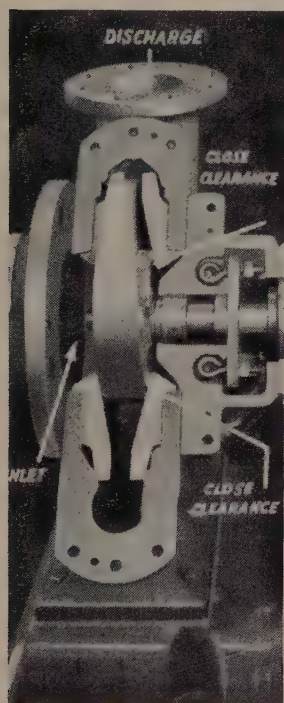


Fig. 164
Construction of a Centrifugal Pump
—Courtesy Shartle Bros. Mach. Co.

more impellers mounted on a shaft and surrounded by a spiral casing. The liquid is drawn into the impeller axially and discharged radially into the casing by centrifugal force created by the rapid rotation of the impeller. Water pumps have what are termed closed impellers, meaning that the vanes are cast between two discs of metal and the seal between the high and low pressure chambers is formed by sealing rings surrounding the

intake openings of the impeller. Stock pumps have what are known as open impellers in which the vanes run between closely fitted stationary discs called shrouds. The general uses of centrifugal pumps at Camas are for pumping water, stock, acid and liquors. They also serve as mixers. The advantages of the centrifugal pump over the reciprocating pump are:

1. Lower initial cost.
2. Less floor space required.
3. Lower maintenance cost.
4. Quiet operation.
5. Elimination of stresses in pipe lines.
6. Suitable for direct motor drive at high speed.

Pump Design

The following discussion covers briefly the basic principles of the relationship of pressure, speed, capacity and impeller diameter of centrifugal pumps.

When the peripheral speed, or the speed at the tip of an impeller, is varied, either by changing the impeller diameter or the revolutions per minute, the following changes are noted:

1. The capacity varies directly with the speed.
2. The pressure or head varies as the square of the peripheral speed.
3. The brake horsepower or input horsepower varies as the cube of the peripheral speed but may be more accurately determined by the following formula:

$$4. \text{ B.H.P.} = \frac{\text{Capacity (U. S. gallons per min.)} \times \text{Head in feet}}{3960 \times \text{Efficiency of Pump}}$$

Let us assume that we have a pump delivering 1000 G.P.M. against a total head of 50 feet, the pump speed being 850 R.P.M. and the efficiency 70%, with a 12" diameter impeller

Example No. 1. What would be the capacity if the speed were changed to 1150 R.P.M.?

$$850 \text{ R.P.M.} : 1150 \text{ R.P.M.} = 1000 \text{ G.P.M.} : ? \text{ or } 1353 \text{ G.P.M.}$$

Of course, we can't stop here because rule 2 says the head varies as the square of the speed, so

$$850^2 : 1150^2 = 50 : ? \text{ or } 92 \text{ ft. head.}$$

The pump will now deliver 1353 gallons per minute against a head of 92 feet. This however, neglects the change in efficiency of the pump but is as close as we can estimate without actually having a characteristic curve of the pump.

Example No. 2. Starting again with the original conditions, if the impeller

was changed to 10", what would be the new capacity and head:

$$12 : 10 = 1000 : ? \quad \text{or} \quad 835 \text{ G.P.M.}$$

$$12^2 : 10^2 = 50 : ? \quad \text{or} \quad 34.7 \text{ ft. head.}$$

Example No. 3. To find the H.P. required by the pump we have:

$$\text{H.P.} = \frac{1000 \times 50}{3960 \times .70} = 18.02 \text{ H.P.}$$

Example No. 4. What would be the H.P. if the speed was changed to 1150?

$$850^3 : 1150^3 = 18.02 \text{ H.P.} : ? \quad \text{or} \quad 45 \text{ H.P.}$$

Pump Troubles

Locating trouble on centrifugal pumps is probably one of the most important items in connection with conveying and handling materials in the paper mill. Six of the main symptoms of trouble are listed below with a number of considerations, each of which could be the cause.

1. Pump does not deliver any liquid.
 - a. Not properly primed.
 - b. Speed too low.
 - c. Discharge head higher than anticipated.
 - d. Suction lift too high.
 - e. Impeller completely plugged.
 - f. Impeller turning wrong direction.
 - g. Air leaking through packing or into suction.
2. Pump does not deliver sufficient liquid.
 - a, b, c, and d—same as above.
 - e. Impeller partly plugged.
 - f. Not enough suction head.
 - g. Wearing or sealing rings worn.
 - h. Impeller damaged.
 - i. Packing worn out or too loose.
 - j. Water seals on packing shut off or plugged.
 - k. Foot valve too small.
 - l. Foot valve or suction not immersed deep enough.
3. Not enough pressure.
 - a. Speed too low.
 - b. Air in the liquid.
 - c. Ring or shrouds worn.
 - d. Impeller damaged.
 - e. Packing worn.
 - f. Water seal shut off or plugged.

- g. Impeller too small.
- 4. Pump works awhile and then stops.
 - a. Leaky suction line.
 - b. Packing worn or water seal shut off or plugged.
 - c. Suction lift too high.
 - d. Air or gas in the liquid.
- 5. Pump takes too much power.
 - a. Head lower than rating, pumps too much liquid.
 - b. Liquid heavier than water.
 - c. Shaft bent.
 - d. Rotating element binding.
 - e. Speed too high.
 - f. Packing glands too tight.
 - g. Rings worn.
- 6. Pump noisy with excessive vibration.
 - a. Running empty.
 - b. Impeller too large for job.
 - c. Impeller damaged and out of balance.
 - d. Shaft bent.

An idea of the importance of pumps in the Camas mill may be derived from the fact that the combined capacity of the pumps is about 280,000 G.P.M., or 400,000,000 gallons per day, and that the power capacity for pumping is approximately 7500 H.P.

CHAPTER XXXIV

SAFETY

By J. F. ROBERTSON

Development of Safety Recognition

In years gone by, safety measures played only a small part in the business of operating a paper mill. They were given consideration only after the immediate problems of costs, production, maintenance, etc., were disposed of. Such is not the case today. Mill managers have found from experience that a cooperative viewpoint in the matter of accident prevention works to the advantage of both employer and employee. Lost time accidents mean a reduction in income to the worker and an expense to the company in medical costs, loss in production and quality, and in compensation. Also, a bad accident record reflects on the efficient operation of the mill as a whole.

A manager may, at his own discretion, risk mechanical equipment in a gamble for increased profits, but the moment this gamble involves the possible loss of a human life, he is violating a sacred obligation of his industry to his fellowmen. Industry has found out, moreover, that the indirect cost of a lost time accident is five times as great as the compensation and medical expense involved. So, apart from any humanitarian considerations, an efficient safety program is good business.

The management at Camas is aware of these things and stands wholeheartedly behind safety work. Never are expenditures, which are deemed necessary, for guards, goggles, gas masks and other protective equipment, refused. Safety of the employees is one of the first considerations in the affairs of Camas plant.

Organization of Safety Work

The next question is how to organize an efficient safety program, one that will really work. No matter how elaborate the system is, if it cannot command the respect and cooperation of the man in the mill, it is not serving its purpose. The entire plant must be made "Safety Conscious." The results of any system quickly show in the accident records.

Organized industrial safety work in this country has been credited with saving 270,000 lives and preventing 27,000,000 injuries since 1917. The death rate due to industrial accidents has been cut squarely in two since 1913. In 1917 the exact causes of accidents were not known in most

cases, nor were accidents properly analyzed to determine the factors involved. Too often, in those days, explanations of accidents were dismissed simply as due to "carelessness of the workman," without further investigation. Today, causes are known, contributing factors have been identified and some intelligent scientific attack is made to prevent recurrence. We now know that 98 percent of all accidents are, in the last analysis, entirely preventable.

Every worker is subject to human complexes. He worries, he may be fatigued, he is concerned about grocery bills or next month's rent, he is disturbed by domestic difficulties or he may be just plain "day dreaming." These are hazards affecting not only his efficiency and value to his company, but his personal safety as well. The foreman must be alert to these symptoms and do what he can to improve the situation. This is usually a difficult problem and one that the foreman often steers clear of to avoid getting the reputation of butting in on someone else's private affairs. There is no denying the fact, however, that attempts on the part of the foreman to remove mental hazards for his men are distinctly constructive measures.

This line of thought calls to mind the poem "To The Foreman."

"You can lead a horse to water but you cannot make him drink;
You can lead a lad to safety, but you cannot make him think;
You can tell him how to do it, but you don't know what he'll do,
Yet you're his boss and all the time his safety's up to you."

—*Au Sable News*.

This does not mean that the responsibility should be assumed entirely by the foreman. Each worker must do his share. The fact remains, however, that the foreman is the most important link in the chain of safety organization and the success of accident prevention depends largely on him to sustain interest in safety work among his men and see that safety rules are rigidly adhered to.

The Japanese Industrial Development Association several years ago published their "Rules of Safety" which included the following:

1. Even if you feel quite safe, attention once more.
2. The ways to accidents are "Looking away" and "Idle talks."
3. Late hours and the morning accident.
4. Don't throw, don't drop and don't roll.

Expressed in typical style, these rules are sound advice in any language.

The fundamentals of accident prevention, in the last analysis, are relatively simple.

1. Safe structures.
2. Safe equipment and machines.

3. Good housekeeping.

4. Knowledge of the individual in how to do his work properly.

Some people have the idea that older men are responsible for most accidents. Experience in analyzing accident records has shown that this is not the case. Dr. C. S. Slocombe, safety advisor of the Boston Elevated Railway, in a meeting of the Massachusetts Safety Council, stated that younger men are far more prone to accidents than middle aged men. In a survey of accidents over a period of years in several Eastern states, he found that the peak age for accidents was between 21 and 25. This is undoubtedly due to less experience, less skill, and a more irresponsible attitude on the part of many younger employees.



Fig. 165
Camas First Aid Station

Every safety organization should include:

1. Accident facts.
2. Elimination of hazards.
3. Safety program.
4. Creating a safety record.
5. Safety publicity.
6. First aid.

Safety work at Camas is organized along such lines.

SAFETY ORGANIZATION AT CAMAS

Physical Examinations

The work of our safety department is closely associated with Personnel Department activities in determining the physical adaptability of workmen to different types of activity. The majority of men hired are first put on the extra crew. In most cases it is impossible to tell which department of the plant in which they may be required to work which necessitates their being physically able to handle any job they might be sent to fill. One of

the first requirements, therefore, might be termed "physical fitness for any job."

Applicants for employment are referred to the Safety Supervisor immediately after being interviewed by the Personnel Supervisor. The first step is to send the person to a doctor for a physical examination. The result of this examination is returned by the physician on one of the regular forms. The more important things taken into consideration are:

1. Eyes

Vision is probably the most valuable asset we have and it is felt that sending a man to work in a paper mill who does not have two good eyes is doing him an injustice. Don't forget that 40,000 glass eyes are imported each year. They are works of art but can never replace the genuine article. Quite frequently we find that a person may have good vision in one eye, but the other may be poor. Suppose, while at work around the mill, something happens to the good eye, and there are many ways that this might occur. We would feel that, in allowing him to go to work, we were partly responsible for the tragedy of impaired vision or possible blindness. He would be better advised to seek employment in some place where his sight would not be risked.

In testing the eyes, a color blindness test is given. In a plant like Camas where a widely diversified range of colored papers is made, a great many people have occasion to judge pulp or beater furnish colors and shades of paper on the paper machines or in the finishing rooms or converting departments, including colors of inks in the printing department. It is really surprising to discover the number of people who are partly color blind, that is, not able to judge various shades of mixed colors like blue-greens or purples. Usually they have no previous suspicion of deficiency in color judgment.

2. Hearing

A worker must be able to hear the various signals, fire whistles, locomotive bells, gas "mule" horns, etc., for his own safety.

3. Hernia

This condition is watched very carefully and is of course of the utmost importance in any job requiring any amount of lifting.

4. Heart Condition

Quite a number of jobs are of such a nature that should strenuous exertion affect a man's heart, it might endanger his life, as well as the lives of others.

These are a few of the more important conditions covered in the

examination of all applicants for employment.

Safety Rules

If the applicant passes the medical examination and is given a job, we attempt to explain some of the hazards of a paper mill. Each employee is given one of the company rule books, Section III of which is devoted entirely to safety rules. The First Aid Station and the hours the nurse is on duty are explained, also what to do and where to go should an accident occur at night. Attention is called to rules covering use of goggles, respirators and gas masks. The location of first aid boxes and stretcher stations is explained. Plant safety rules are so vitally important to the welfare of each employee that we feel it is not amiss to quote these in this book even though employees have them already in the rule book.

SECTION III GENERAL SAFETY RULES FOR CAMAS MILL

DEPARTMENTAL SAFETY RULES

1. All departmental safety rules must be observed.

ACCIDENTS WHILE AT WORK

2. When an employee meets with an accident he shall, as soon as possible, avail himself of the first aid equipment in his department.

If an employee meets with an accident requiring immediate medical attention, he shall, if circumstances permit, report to his foreman, who will release him to the nurse, if there be one in attendance at the plant, and/or to a local doctor approved by the State for the provision of Industrial Medical Aid to such employee.

Every employee shall be required to report to his foreman any and all accidents no matter how slight.

SAFETY DEVICES

3. All safety devices installed must be used. Guards must be in place before starting any equipment which has been down for repairs.

Report at once all unsafe conditions and practices to your foreman or through the suggestion box.

GOGGLES

4. Goggles shall be worn by all employees when performing any of the following operations:

- (a) Chipping concrete.
- (b) Chipping steel.
- (c) Handling acid on paper machines.
- (d) Handling storage-battery fluid.
- (e) Working on smelter spouts and nozzles.
- (f) Grinding with stones except where shields are provided, in which case shields must be set in place.

ELECTRIC WELDING

5. Arc work must be screened, whether performed in the field or shop.

EMERGENCY GAS MASKS

6. After gas masks have been used in an emergency, they are to be turned in to the storekeeper who will sterilize mouthpieces and replace canisters with new ones. Storekeeper will turn partly used canisters over to pipefitters or digester cooks who will use them until empty.

ELEVATORS

7. Employees shall observe all rules posted at elevators.

ELECTRIC TRUCKS AND TRAMWAY VEHICLES

8. No employee other than the operator is permitted to operate or ride on electric trucks. No employees, other than the operators and those supervising the movement of materials and equipment, are permitted to ride on tramway vehicles.

Employees operating electric trucks shall observe the following rules:

- (a) Sound horn of truck at turns and blind spots.
- (b) Slow down for corners.
- (c) Trucks to be brought on elevators with loading end forward.

OVERHEAD PLANKS AND PLATFORMS

9. All planking and staging must be safely secured and after completion of job must be removed.

BULK MATERIAL STORAGE

10. All bulk or sacked material must be moved so that overhang does not occur. This applies to all chemicals, hog fuel and chips, and to wood piled in the bins in the Groundwood mill.

PAPER MACHINE CALENDERS

11. Put paper through calenders with a foot of paper projecting from the hand toward the nip.

CHANGING BELTS

12. Do not attempt to put belts on or off pulleys while machine is running. SHUT DOWN. Start up at slow speed until belt is safely on or off. Non-observance of this rule by employees means a lay-off or discharge.

After explaining the nature and purpose of safety work to the applicant, he is now ready for work and the employment office is so advised.

Camas Medical Service

Should the employee so desire he can subscribe to the Camas Medical Service for a small monthly fee deductible from his pay check. This service is designed to give him or her medical care for sickness and accidents that occur outside working hours. Where special treatment is needed, patients are referred to specialists in Portland or Vancouver. This plan covers all manner of non-occupational cases, automobile accidents, contagious disease, etc., and results in a healthier plant personnel as many employees would otherwise be unable to secure proper medical care for financial reasons.

Group Insurance

A coverage plan has been written by one of the large insurance companies whereby an employee may voluntarily become eligible for its benefits by payment of a monthly fee, also deductible from his pay check. By means of weekly payments proportionate to his normal income, this plan compensates the worker for lost time resulting from sickness or accidents of a non-occupational nature. It also provides for term life insurance up to a certain age limit.

Safety Committees

In order to properly carry out the work of accident prevention, three groups or committees have been organized to assist the Safety Supervisor.

Workmen's Committee

This committee is made up of men from the various departments in the plant. We try to have every department represented at each of the meetings which are held regularly every two weeks. Any accidents that have occurred since the previous meeting are reviewed and discussed in detail. Mill accident records for the month and the year to date are gone over and comparative figures from other mills are examined. It is always the practice at these meetings to call on the committee members for suggestions, which are discussed carefully. After the meeting, these suggestions

are typed in duplicate, one copy going to the superintendent of the department concerned, the other being retained in the safety supervisor's office for a follow-up to make certain they do not get lost or sidetracked. These suggestions are never allowed to die a natural death and at the next committee meeting a report is made on what action has been taken on each.

Occasionally, after a meeting, we divide the committee up into groups and visit different departments of the plant where a "surprise" checkup is made on tools, trucks, hoists, guards, lighting, sanitary conditions, etc.

The members of this committee are selected by the foreman, a new committee being chosen every three months.

Foremen's Committee

Once each month all the foremen in the plant get together to review in detail any accidents and discuss accident records. This meeting is similar to the workmen's committee meetings except that special efforts are made to impress on the foremen their responsibility in contacting each workman personally and in keeping his interest and enthusiasm in accident prevention aroused. In many cases there is a hesitancy on the part of an employee to approach his foreman, hence our efforts to have the foreman go to the men, realizing that the man on the job is in the best position to point out any unsafe conditions that might exist.

Superintendent's Meetings

Once each week departmental superintendents meet to discuss problems of costs, maintenance, production, etc. These meetings are presided over by the mill manager. In spite of the large amount of work handled at these meetings, considerable time is always allotted to discussion of accident cases and records. The importance of safety work is continually impressed on this group.

Keeping Accident Records

We attempt to keep a complete record of all injuries sustained by every employee. Every injury treated by the plant nurse is recorded, showing the employee's name, department in which he works, nature of the injury and the treatment given. Some are of the opinion that reporting to the First Aid Station for minor injuries and having to answer these questions, goes against their record. Such is not the case. In fact, an individual would be open to censure for not reporting and having proper treatment. We are continually trying to convey to everyone the importance of proper care of minor injuries.

Industrial Injury Report

After the nurse has been contacted, should she be of the opinion that

the case should be referred to a doctor, or if the employee himself considers it necessary, an order is given him to consult any local doctor of his own choice. For all cases requiring medical attention, we have to make out an Industrial Injury Report. In this report, the following details are filled in.

1. Name, age and occupation of employee, also length of service with the company.

2. Time and place of accident. This is mostly for our own information to have a record of the department concerned and the exact location in that department.

3. Witness to injury. In the event that any question should be raised concerning details of the accident.

4. Injured's report of accident. Here the injured employee is asked to describe in his own words how the accident occurred, what machine or tool was involved and exactly how he was injured, also what recommendations he would make to prevent the accident happening again.

5. Foreman's report of injury. This is filled in from a separate report made by the foreman.

6. Nature and severity of injury. General description of injury.

7. Accident causes. This covers all contributing factors, such as defective tools, materials improperly piled, faulty guards, etc.

8. Type of accident. Designating whether it occurred as the result of lifting, falling, saw cuts, burns or whatever it might be.

9. Nature of injury. Covering the exact result of the accident, that is whether it produced a cut, burn, fracture, sprain, etc.

This form, when completed, is carefully gone over and studied in detail so that the information thereby accumulated can be constructively used to make the mill a safer place for the workmen.

Foremen's Accident Report

This is compiled on a separate form and covers the following points chiefly.

1. When accident occurred.

2. Occupation of injured person.

3. What was he doing when accident occurred.

4. Location where accident occurred.

5. Nature of injury.

6. Probable cause of accident.

7. How can a similar accident be prevented?

8. When did you receive first report of accident?

9. Could the accident have been foreseen or prevented by a more rigid inspection of equipment prior to the accident?

10. Could the accident have been prevented by more or better job training?

11. Did the accident result from the equipment being wet, dirty, or in poor mechanical repair?

12. Did this condition arise through neglect, nature of service or location of equipment?

State Industrial Accident Report

Where an injury requires medical attention, this report is made out and covers three sections:

1. Workman's Report. Information similar to the Industrial Injury Report.

2. Employer's Report. Covering date and time of accident, date quit work and date returned to work, the industrial classification and the report on how the accident occurred.

3. Physician's Report. His diagnosis and treatment.

You might think that these reports involve considerable "red tape" and duplication of information. However, to make any progress in accident prevention it is essential to have full and complete details so that the proper steps can be taken to prevent some other workman being injured in a similar accident.

Monthly Accident Report

This report contains complete information, by departments, for the entire plant, showing hours worked, number of minor injuries, number of first aid cases treated, number of lost time accidents, and days lost. It also shows the frequency rate and severity rate for all lost time accidents.

The Frequency Rate is the number of lost time accidents for each million man hours worked. For example, four disabling injuries occurring in a month in which 236,636 man hours had been worked would give us a frequency rate of 16.90. This method of calculating the frequency of accidents is generally used throughout the country and allows us to compare our records with those of other paper mills and other plants manufacturing different products.

The Severity Rate is the total number of days lost per thousand man hours. In cases where a permanent partial disability occurs, a theoretical figure for days lost is used. For example, if a man should lose three fingers on one hand in an accident, 1200 days would be used for lost time in calculating the severity rate.

Annual and Quarterly Reports

Frequency and severity rates for each month are accumulated and a complete report compiled at the end of the year. A quarterly report is submitted to the head office in San Francisco containing complete accident data for the period. All mills in the Crown Zellerbach group send in similar reports from which a combined report is compiled at San Francisco for comparison. This information is made available to the superintendents, foremen and employees to promote interest in accident prevention.

Publicity

Bulletin boards are placed in prominent locations throughout the plant, carrying printed notices and attention-compelling pictures. These are of the utmost importance in making the plant safety conscious, to make everyone "Think Safety" at all times. A large bulletin board is located just outside the main entrance to the mill and shows day by day the accident record for each department.

Compensation

Compensation, or as it is termed by the State, Industrial Insurance, is the fund contributed to wholly by employers and is used to pay injured employees for time lost from work and permanent partial disability resulting from industrial injuries. This contribution by the employers is based on the amount paid to employees for the previous five-year period, at an established rate per hour of exposure. The amount of compensation paid is established by the State and is based on a man's marital status. A married man receives more than a single man, increasing according to the number of dependents.

The Medical Aid Fund is contributed to equally by employer and employee, being deductible from pay checks. From this fund doctor bills, hospital and medicine costs involved in occupational accidents are taken care of.

If a man goes off the payroll due to accident or sickness, the company realizes that his duties have been suspended due to circumstances beyond his control, and his job is waiting for him when he is able to return to work, unless the accident occurred as a direct result of carelessness, neglect or disregard for safety rules.

First Aid

For the past seven years, instruction classes have been held at Camas in the study of first aid. Over five hundred employees have successfully completed and passed the training course of the American Red Cross. Local doctors unselfishly devote their time and efforts to further this work.

First aid teams from this plant have made high standings in competition with other teams from other parts of the State. This training is of inestimable value to the general welfare of the community in emergencies arising in social and recreational pursuits outside the confines of the mill proper.

In this course of training, stress is placed on the two primary objects of First Aid, first to prevent accidents BEFORE they happen, and second to know what to do WHEN they happen. Such knowledge may prevent death in severe cases and in less dangerous cases prevents further pain and injury due to hemorrhage, infection, shock or compounding of fractures and puts the injured person in the best possible condition for medical treatment.

Safety Equipment

All safety equipment, goggles, gas masks, etc., is inspected and maintained in working condition at all times. Between periods of use, this equipment is maintained as far as possible in a sterilized condition to prevent possible transmittal of disease or infection among workers using the same equipment.

Manufacturers of safety devices have been alert to recognize the problems of combating industrial hazards, particularly toxic hazards such as exposure to sulphur dioxide or chlorine gases. The result has been the development of special types of improved equipment designed not only for the safety but for the comfort of the wearer. Special type safety shoes and rubber boots with reinforced toes have been developed and their use is encouraged as much as possible at Camas. New types of goggles have been developed with shatterproof, wide angle of vision lenses, splash proof, non-fogging, and with good quality non-refracting lenses to avoid eye strain. Such a simple thing as fogging of goggles when a man is busy with both hands may be the chief factor in causing a serious accident. Special color ultra-violet light absorbing lenses have been developed for welding.

The U. S. Bureau of Mines has made such a complete and authoritative study of respirators and gas masks that few industries would think of using equipment of this nature unless recommended or approved by the Bureau.

Occupational Diseases

The Association of Casualty and Surety Executives, representing some sixty of the leading casualty insurance companies, which group writes a substantial volume of workmen's compensation insurance, last year undertook a survey of all occupational diseases. They concluded that death or disability resulting from an occupational disease entitled the worker or his dependents to compensation exactly the same as an accident. Thus, attention is being given to the health of a workman as well as to his exposure

to accident hazards. This Association considers the work of preventing occupational diseases as far more important than working out any scale of compensation. No one will deny the fundamental truth and logic of that statement. In the State of Washington the Compensation Act was amended

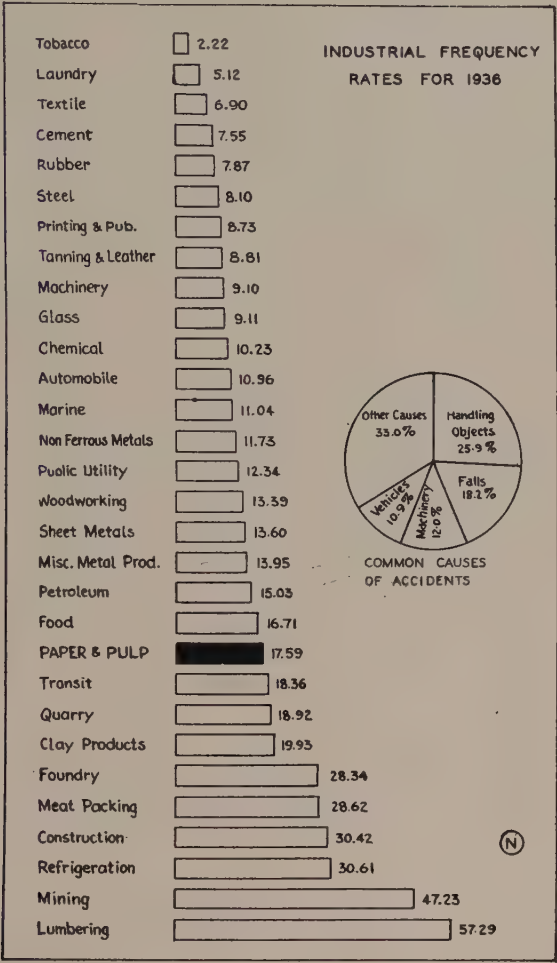


Fig. 166 Compiled from National Safety Council Statistics

in 1938 so as to include under compensation benefits to industries within the State, a schedule of 21 specific occupational diseases. Although still in a formative stage the serious attention that is being given to occupational disease prevention and control marks another milestone in the march of Safety progress.

The Future in Safety Work

Let us take a look at the position of the pulp and paper industry in the matter of accident occurrence compared to other industries. Fig. 166 shows that our industry holds an intermediate position with a frequency rate of 17.59 for the year 1936. It is a less dangerous industry than lumbering, mining, refrigeration and others at the bottom of the scale and more dangerous than the tobacco, laundry, textile, cement and other industries near the top of the list. The ambition of each one of us should be to do his or her part to boost the position of the pulp and paper industry from twenty-first place to the top of the list. The steel industry with a frequency rate of 8.10 has achieved a splendid record. The explosives plant of the DuPont Co. at DuPont, Washington, operated for years at a zero frequency rate. The Consolidated Gas Co. of New York, in a seven-year period, cut their annual lost time accidents from 1,230 to 201, representing a reduction in frequency rate from 14.93 to 2.38. The Anderson, Indiana, plant of the American Steel and Wire Co. established a record of six years and 34 days without a lost time accident until a workman fell off a ladder. In a 5-year period, more than two billion pounds of commercial explosives have been transported over the railroads of the United States and Canada without a single loss of life and with a money damage of only \$213.00.

While the standing of the pulp and paper industry is twenty-first compared with the other industries, safety work has without question saved many lives and prevented many injuries. The success in this work is measured entirely by the sum of the individual efforts of those concerned and every employee in any plant shares the responsibility of promoting safety not only for himself but for his fellow workers.

Remember the Four Horsemen of the Apocalypse—Fire, Famine, Pestilence and Death—still ride in industry. Human carelessness is yet the largest factor contributing to high accident rates. Stop to think and you'll think to stop. Be careful. Keep your feet warm and your head cool.

CHAPTER XXXV

ENGINEERING — MAINTENANCE

By G. W. CHARTERS

PART I—ENGINEERING

The Engineering Department at Camas through its program of investigating, selecting, designing, laying-out and coordinating equipment and structures, plays a very important part in the performance of the entire mill. The scope of its work is very broad, embracing a range from surveying a company lot to rebuilding a paper machine; from sketching a stock flow diagram to laying out a new digester installation; from determining the proper pump for a given service to designing a wood storage bunker.

The work of this department is carried on by a group of engineers headed by a qualified mechanical engineer and assisted by men with various types of engineering training. All of the work is under the direction of the supervising engineer who is responsible to a member of the Mill Management Staff in charge of operations and maintenance. Their offices are on the top floor of the main office building and are known as the Engineering Department. This includes the space for drafting rooms and all necessary blue printing equipment.

At times, as during periods when major construction jobs are in progress, it is necessary to supplement this group of men with additional help.

This arrangement serves to knit the Engineering Department very closely to the operating departments and helps to coordinate the engineering and maintenance work, certain phases of which naturally tend to overlap in some degree.

It is typical of manufacturing industries that all associate departments, such as accounting, personnel, maintenance, laboratory, engineering, and the like, which are not engaged directly in the processing of materials as are the operating departments, function more or less as service units to the latter. The situation can be likened to that in which all the various engines or motors driving the related auxiliary equipment, such as pumps, blowers, screens, and so forth, coordinate their functions to net the best possible performance of the integral paper machine.

In this sense, the Engineering Office is a service department to the Wood Mill, Sulphite Mill, Kraft Mill, Paper Mill, and other operating

departments. More broadly, however, it is a research and development department, continually seeking out, investigating and developing new ideas, new machinery and equipment, and improved materials, methods and processes which may be effectually employed to simultaneously decrease operating costs and increase the quantity and quality of the mill output.

All of the engineering work is approached and conducted with several aims. First of all, every effort is made to provide precisely the equipment and arrangement that has finally been determined upon by the department heads and mill executives. It follows, of course, that insofar as possible under given conditions, all designs, arrangements and selection of materials and equipment are based on the best known engineering practice.

Safety:

Another aim is safety—safety of equipment and safety of personnel. All layouts and designs are prepared with the intent of minimizing unsafe practices. In this progressive age that phase of engineering aim also embraces the effort to eliminate heavy lifting and other forms of straining, over-fatiguing or discomforting labor. Thus, attention is given to mechanizing additional operations. Heating and ventilating systems are installed. Much of the irk is removed from work by providing refined automatic instruments and devices to assist in the measuring, recording and controlling of processes.

Appearance:

General appearance, too, must be considered. Equipment or structures that do not fit into the scheme of things, or that do not lend themselves to being kept clean and tidy, are not acceptable.

Costs:

Naturally, many times projected plans are not consummated because the required expenditure appears high in relation to the benefits expected. It is noteworthy, however, that it is not the policy to permit the sacrifice of safety features or of recognized standards of design and construction in order to reduce estimated costs. At the same time, all projects are, of course, developed with a view to making the proposed installations with the minimum expenditure necessary to net the desired results.

Classifications of Work:

Regarding the work assignment procedure, the diversified nature of the types and proportions, make it imperative that each member of the limited staff have quite general training, the flexibility of the group would be severely cramped if each man were strictly specialized. On the other hand,

a certain amount of specialization is advantageous; and thus it evolves that the requests of engineering work are roughly classified according to following groupings:

1. Design and installation of automatic machinery.
2. Design and installation of heavy machinery.
3. Structural design and construction.
4. Surveying and mapping.
5. Appraisal drawings and mill information sheets.
6. Records of spare parts, motors, pumps, tex-rope drives, etc.
7. Directo photo printing and charting.
8. Project work, such as making preliminary studies and layouts, investigating new types of equipment, obtaining data and prices, estimating benefits expected, etc.
9. Investigation of reasons for proposed changes and improvements, including preparation of AFE (Authorization for Expenditure) explanations and of savings estimates when applicable.
10. Estimating of cost of jobs and preparation of AFE's.
11. Ordering of equipment and materials.
12. Supervision and inspection of plans and procedures in contract jobs.
13. Miscellaneous.

Work Orders:

Requests for work by the Engineering Department may be received directly or indirectly from any foreman or department head in the mill, or directly from the management. As a general thing, to provide a record the requests are put in writing, either in the form of work orders, which are memorandums that indicate the work desired, by whom requested and the account to be charged with the expense, or in the form of blue note memorandums.

In this connection, work order requests for emergency or regular maintenance or construction jobs not considered large enough to require special approval by the management, are approved directly by the maintenance foreman and are executed by his force. All others are routed to the engineering department, commonly with estimates of shop work noted on them if the job requires such.

The supervising engineer classifies all requests received by him, and as the situation demands, either prepares AFE's directly or assigns the requests to his assistants for development and preparation of any sketches or drawings that may be required.

Price quotations on materials or equipment required in the preparation of estimates are obtained through the Purchasing Department which in turn keeps the Engineering Department informed as to the shipping dates and the like.

Authorization for Expenditure:

Upon completion of the plans for a project, a final estimate of the cost of the various elements is compiled and an AFE is prepared.

The AFE must show the expected amount of the expenditure for each phase of the job and must indicate the distribution of the total to capital addition, maintenance, demolition expense, and so on, as segregated by the Accounting Department. It must state exactly the nature of the work or purchase proposed and must explain precisely the purpose or necessity together with expected benefits. Also, in the case of equipment purchases, it must specify the proposed vendor or supplier.

All AFE's other than those for sundry plant expenditures which are below certain stipulated amounts and which may be executed upon approval by the department head and by the local mill management, require the formal approval of the department head, of the local mill management, of the Portland office and of the San Francisco office. If and when this approval is granted, the work or purchases may proceed as feasible, either by the local maintenance and construction crews, or, if a very large job, by outside contractors. In any case, the Engineering Department cooperates in every way possible and follows up with necessary supervision and inspection.

Because of their extreme importance and utility a word of explanation should be added concerning the appraisal drawings and mill information sheets. These drawings show the location and relationship of every building, structure and piece of equipment in the mill; and the information sheets list in detail such facts as are necessary to identify each item by make, size, type, speed, and so on, including a statement of the exact service to which each unit is assigned. Considering the number of changes that are continually being made in a mill of this proportion, it may well be imagined that to keep the appraisals closely up to date, as must be done, is no small task in itself. One of the requisites is a definite channel through which any changes of equipment, such as switching of pumps, motors, and the like, made by the maintenance department may be reported to the engineering office.

It naturally behooves the Engineering Department to keep complete files of all sketches and design and construction drawings, both of current work and of prior projects and installations, whether performed by the

company's own men or by outside contractors.

Progress and Development:

Much benefit is derived from exposure to current magazines that describe what others in similar industries are doing, and many helpful ideas are gleaned from the various salesmen and advertising bulletins that come to the office. Beyond this, it is considered very desirable that a few selected industrial periodicals be on hand in the department at all times.

In the same vein, all of the engineer's work cannot satisfactorily be performed with slide-rule and drawing instruments. Hours of time, and possible serious errors, are saved by having appropriate books of data and tables at his finger tips.

The engineering office is equipped with what is known as a "Directo" printing outfit. This is a photo process somewhat like blue-printing, by means of which reproductions of sketches and drawings on translucent paper can be made quickly and cheaply. This is an invaluable service. It makes it unnecessary for the original drawings ever to leave the Engineering Department, thus avoiding loss and damage.

PART II—MAINTENANCE AND CONSTRUCTION

The Maintenance and Construction Department which is a service department for all operating departments and active in every phase of mill operations, is quartered adjacent to the machine shop.

Several types of maintenance and construction departments are in use in paper mills, the size and kind of mill generally fixing the type most suitable for best results. The organization at Camas has been developed over a period of years and seems to meet the requirements for providing the best service at the lowest cost. In developing this organization in step with the expanding of the mill in physical properties as well as higher productive units, consideration has to be given to provide a qualified staff of men to handle the various phases of the work. In smaller mills these duties can be assigned to one individual, sometimes called the paper mill master mechanic. In Camas these duties are assigned to a group of individuals headed by a graduate mechanical engineer, whose title is mechanical superintendent, and who is responsible to a member of the management staff. This group of men supervises what may be classed as three divisions in this department—Maintenance, Construction and Shops, whose normal crews comprise about 100 men, but in times of major developments or expansions, may number over 200 men.

These divisions have in their personnel various kinds of mechanics. In the shops there are machinists, tinsmiths, sheetmetal workers, welders,

both electrical and acetylene, blacksmiths, pipefitters, pattern makers, saw filers, cylinder mould repair men, and roll grinders; in the maintenance division are millwrights, rigger crews, painters, carpenters and laborers; and in the construction division are carpenters and helpers.

In addition to those listed as personnel of these three divisions there are men assigned to several of the larger departments to take care of all maintenance work, performing their work under written orders from the department head, but responsible to the mechanical superintendent for the proper execution of the order. This procedure enables the mechanical superintendent and his staff to become thoroughly familiar with every detail of the maintenance requirements in these departments. It also makes possible the maintenance of minimum crews for normal week-day operations. Listed herewith are the departments maintaining groups under an assignment from the maintenance and construction department: The Paper Mill and beater room department have a foreman, millwright and usually 13 to 15 men. This includes four shift men, as it is advisable to keep a qualified millwright in attendance in these departments during the 24-hour operating period. These men are all journeymen mechanics well qualified to handle all mechanical problems arising as mill maintenance work. It has been found advisable to have men in this group specialize in certain types of work. Their years of experience around paper machines and beaters make them better qualified to perform the maintenance work, and therefore, the objective of assigning these men to this department is warranted.

To the Sulphite Mill is assigned a millwright foreman and three or four helpers. These men are qualified to carry the specialized maintenance work found in this department.

The Kraft Mill is serviced by a mechanic and pipe fitter.

The Saw Mill has millwrights and helpers and the Chipper Room a millwright.

The Bag Factory and Converting Plants have special equipment and maintain their own staff of mechanics as well as a separate shop and this comes under the direct supervision of the department heads.

This also applies to the Steam Plant and Turbine Room where special equipment and specially trained men are required for the maintenance work. They also cover the steam engines driving some of the paper machines.

The Electrical Department maintains a regular crew of electricians and helpers and this group is a separate organization directly responsible to the chief electrician, who in turn, is responsible to a member of the management staff.

When the mill is operating on a 24-hour schedule, minimum crews are maintained in these departments. During the time down on weekends and where there is a 24-hour shutdown period on Sunday, the major repairs are done at that time, and it is necessary to supplement the normal maintenance crews in all departments to handle the additional Sunday work. This is done by taking men from the extra board, or from various departments in the mill, which procedure tends to improve the personnel of these maintenance groups and affords a means of training men in maintenance work. In most cases the men used on week-ends are those who seem qualified to follow maintenance work. Because of the weekly hour limitation, these men who work week-ends and Sundays are obliged to take time off from their regular jobs, but as this can be done without interfering with the efficiency of the department from which they may come, it also offers an opportunity for other men to train for these jobs.

The most effective way to direct this group of men is through the Work Order system. These work orders originate with the department heads requiring maintenance work, and are made out in triplicate and addressed to the division of maintenance, construction, or shops, as the case might be. Two copies are delivered to the office of the mechanical superintendent, the third is retained in the book in the department, the maintenance department acting as a clearance house for the work orders. If the work requested comes under the head of regular maintenance, the foreman who is to execute the order is given the original copy and the duplicate remains in the files of this office. If the work order is a request for work other than normal maintenance it may be held in the superintendent's office and one of his group will make an investigation to determine the expenditure necessary and, from an engineering angle, will make his recommendation as to the desirability of the request. If the expenditure is of a minimum amount, the job may be approved by a member of the management staff. If the expenditure is for a substantial amount, further investigation may be made by the management staff and it may be advisable to approve the expenditure against Sundry Plant Account. If the amount of the expenditure exceeds a stipulated amount, then the order is passed on to the Engineering Department, where the standard form of request is prepared, known as Authorization for Expenditure. The procedure then is to make a survey of the job for economies or other advantages the expenditure might justify. The savings or benefits may warrant the approval or not, as the case might be.

Summarizing the function of the work orders, the most of which are issued for normal maintenance work, they may be divided into three classes: First, work orders covering normal maintenance, such as the

adjustments of machinery, repairs or replacements of parts; second, those covering requests for work with an expenditure not normally classified as maintenance, in which case this work may be divided into two classes—that which can be capitalized and charged against Sundry Plant Account, and that work which has no capital value but covers the rearrangement of existing equipment for some particular purpose; and third, work orders covering major repair and replacement jobs and work or equipment where expenditures would exceed a stipulated amount.

The outline given herewith of the purpose of the work order system quite definitely establishes the fact that the maintenance and construction crews are working on very definite orders originating in the various operating units of the mill, therefore, the expense of their services is distributed to the departments where the order originated.

In outlining the duties of the supervising group, some of the specific duties which have been assigned to the various individuals are listed herewith:

The Mechanical Superintendent's group of assistants and their duties are as follows:

His immediate assistant's schedule is:

1. General supervision in his absence, and on Sundays follows up on work which is scheduled for completion Sunday night.
2. Assists in planning and outlining work for Sunday.
3. Follows up on supervision of the sheet metal shop, painters, miscellaneous maintenance crews and regular construction crews.
4. Investigation of suggestions and attends suggestion meetings.
5. Special engineering investigations and estimates.

The second member of this group has the following duties:

1. Directs supervision of the mechanical inspectors, knife grinder, saw filer and pattern maker.
2. Engineering services, such as:
 - (a) Testing equipment.
 - (b) Obtaining information on proposed changes.
 - (c) Designing and sketching, mostly for field service.
3. Investigates and makes estimates on work orders, and complete estimates made for shop foremen.
4. Takes charge of construction work in the prolonged absence of assistant foreman, or when he is acting in a supervisory capacity.

The next member of the group who is in charge of spare parts and salvage:

1. Keeps all records of spare parts for equipment, Wood Mill, Chipper Plant, Kraft Mill, Sulphite Mill, Paper Mill and Beater Room and is responsible for having spares when needed.
2. Has direct supervision of the salvage department and shipping of the scrap materials.
3. Orders material for use by shops and maintenance and construction crews.

The next member of this group has a title of Mechanical Inspector and covers all outside departments where this organization has supervision over maintenance and construction, making complete inspections in these departments, and has complete supervision of the maintenance work performed by the crews. The Mechanical Inspector is also assigned to the paper machines and beater room, makes detailed inspection of all equipment in the paper mill, makes belt tension tests and keeps up the belt records.

The lubricating department is headed by a foreman, who, through years of experience with machinery, is well qualified to maintain a high standard of efficient lubrication for those departments he serves. Under his supervision careful check is made on the efficiencies and work performed by the oilers in the paper mill. As a considerable amount of oiling is done by the operators it is necessary to make provision to have convenient oiling stations serving various units of the mill. These oiling stations are kept supplied with the types of oils in use so that operators will always have a sufficient supply available. Under this foreman oiler's supervision a large amount of reclaimed oil is salvaged, and, in addition to the responsibility of his men supplying oil to the different stations, they also reclaim a large amount of oil from the various reclaiming units throughout the mill. This foreman oiler works under the supervision of the Mechanical Superintendent and cooperates very closely with the department heads so that their oilers may be more effectively supervised.

Certain objectives are set up by mill management in evaluating the result of the maintenance and construction departments. Our executive management, during past years, have found it advisable to engage the services of the inspection staff of an insurance company. This company carries the insurance on practically all moving parts of a paper mill. As an example there is complete insurance on a motor failure on all motors over 100 H.P. capacity. In the mechanical part of this insurance all driving equipment is insured, steam engines as well. It also covers the line shafts,

frictions and dryer gears. Certain parts of pumps are covered, such as the shafting.

The insurance company, through their representative in the mill part time, also supplies a mechanical or electrical inspection, which is an additional protection against mechanical or electrical interruptions.

The principal objective of the supervisors in the maintenance department is to avoid interruption of operating time. Through adequate inspection service losses of operating time have now been reduced to a very low figure for what are recognized as high speed machines. In every case where a failure occurs which causes delays in operation, a form is filled out by the department head, outlining just what caused the failure. From there it goes to the mill management office, where it is checked to determine whether there is any insured value involved. From there it is returned to the Mechanical Superintendent's office, where an investigation is undertaken and their recommendation is sent in with the objective of preventing a recurrence of a failure.

CHAPTER XXXVI

INSTRUMENTATION

By O. T. DEFIEUX

What was perhaps the first application of instruments for industrial process control was the simple indicating pressure gauge.

In the development of the machine age where the steam power plant was the most influential factor it became necessary that the pressures maintained in the operation of steam boilers be indicated correctly in order that equipment would not be operated at pressures higher than it was designed to withstand.

With the use of steam for heating in numerous industrial processes, it also became necessary that temperatures be indicated correctly and while it was true that the thermometer was developed many years prior to the machine age, this simple class of instrument became necessary in all industrial processes where heat was a major factor.

It is obvious that a simple indicating pressure or temperature gauge had a value only at the instant that such an instrument was being observed by an operator and it is evident that a record of such a pressure or temperature over a definite time period would be of considerable value in analyzing the results of any such process. Thus came about the development of pressure and temperature recording equipment which utilized the simple mechanism of the pressure or temperature indicator and supplemented that with the time mechanism driving a paper chart upon which could be recorded the pressure or temperature.

From the stage of indicating and recording, the natural advance was for equipment which would automatically control pressures or temperatures, thus relieving the operator of a large amount of detail work and, in general, resulting in a more uniform pressure or temperature being maintained which invariably increased the quality of the product.

So, at the present day stage of instrument development, we are now able to obtain equipment for the automatic control of pressure, temperature, flow and moisture content.

Pressure Indicating, Recording and Controlling Equipment:

For the recording of pressure in any system it is general practice to make use of the principles of the bourdon tube which was used in the

simple indicating pressure gauge. The Bourdon tube is a coiled or bent hollow tube having an elliptical cross section which under pressure tends to straighten out this tube. One end of the tube is, therefore, fixed and the free end of the tube, the position of which will vary under different pressures, is connected to a link mechanism, which in turn is connected to a pointer or indicator. This represents the simple indicating pressure gauge. The medium of which the pressure is desired to be indicated is piped directly to a connection at the end of this bourdon tube. In the recording pressure gauge the pointer is equipped with a pen which instead of indicating over a graduated dial moves over the face of the paper chart which in turn is driven by a mechanical or electrically operated time clock and thus the pressure over any given time may be recorded.

If it is desired to automatically control the pressure in a process this recording pressure gauge may be supplemented by additional equipment and generally mounted within the same instrument case. Compressed air as a medium is quite often used for the automatic control of most pressure, temperature and flow systems, and with such an application compressed air is led to the instrument case and with an increase or a decrease in pressure, temperature, or flow, more or less air may be admitted to a pressure diaphragm which becomes the actuating mechanism to open or close a valve supplying the source of pressure, temperature or flow.

Temperature Indicating, Recording and Control Equipment :

For the indicating, recording and control of temperature a rather wide variety of principles is utilized. The simple indicating thermometer works on the principle of expansion of the mercury or, in some cases, the alcohol in the thermometer. This system is also used in industrial applications for temperature control equipment within certain temperature ranges. Other classes of temperature recording and control equipment make use of the pressure of a liquid which then acts through a bourdon tube and becomes in general a pressure class of equipment. Most liquids have a definite vapor pressure at a certain temperature. Ether is the most common liquid used.

Occasionally thermometer bulbs are filled with a dry gas such as nitrogen which expands directly proportional to its absolute temperature when free to do so. If the gas is contained within a closed system there is a definite increase in pressure due to an increase in temperature and for certain applications the gas-filled bulbs are used in a similar set up to the vapor tension type previously mentioned.

Another principle upon which temperature recording and controlling equipment will function is that due to the electric conductivity. It is a

known fact that the resistance of most electrical conductors will vary with a change in temperature. Thus, if we place such an electrical conductor in the path of a medium, the temperature of which is to be measured, we can record changes in temperature by electrical means. Such an instrument is called an Electrical Resistance Thermometer. The usual resistance thermometer equipment consists of a pure nickel or pure platinum resistance unit enclosed by a protecting tube. This assembly is called a bulb and is located at a point where the temperature is to be taken. The two leads of the resistance unit are connected to a Wheatstone Bridge circuit by which the changes in bulb resistance due to temperature changes are indicated or recorded by the bridge galvanometer. The galvanometer in such a circuit is calibrated in units of temperature either °F. or °C. instead of electrical units. Nickel resistances are generally used for temperatures up to 300° F. and platinum for temperatures up to 1000° F.

Instruments used for measuring temperatures in excess of 1000° F. are generally classified as pyrometers and the science of such applications—pyrometry.

For the measurement of high temperatures the thermo-electric method has come to be far the most largely used.

Discovery of thermo-electric currents was made in the year 1821. It was found that when two wires of different metals are fused together at one end and the free ends are connected by wires to a sensitive electrical instrument (a millivoltmeter) the voltmeter will indicate that a current is flowing if the junction of the two wires is heated. The millivoltmeter may be calibrated in terms of temperature °F. or °C. The junction of the two dissimilar metals is called a thermocouple and the entire instrument an Electrical Pyrometer.

Although any two dissimilar metals might be used for a thermocouple the following combinations are most satisfactory for the designated maximum temperatures:

Maximum Operating Temperature		Composition of Wires	
° F.	° C.	Positive	Negative
3000	1600	Platinum Rhodium	Pure Platinum
1800	1000	Nickel Chromium	Nickel Aluminum
1400	760	Nickel Chromium	Constantan
1200	650	Iron	Constantan

The increase in electro motive force (E.M.F.) due to the rise in temperature of the hot junction of the thermocouple does not bear a constant

relation to the temperature throughout the entire range, therefore thermocouples and instruments must be carefully calibrated. Each of the above principles for the measurement or control of heat have definite fields for which they are most suitable, and the following few applications made in our Camas operations of these different types will help the student understand their respective applications and limitations.

For measuring the temperature within the driers of the paper machines the vapor tension type of bulb is used and the common range of the instrument is from 0 to 270° F. For the measurement of high pressure and temperature of superheated steam, also the temperature of flue gases leaving the boilers both of these ranges approximating around 600° F. the gas-filled bulb type of thermometer is used. The only electrical resistance type thermometer application in use is on the time temperature control equipment of the new experimental digester. The range of this is from 0 to 350° F. The thermocouple principle is essentially used for high temperatures and this class of equipment is utilized to record the combustion chamber temperatures of the sulphur burners in the sulphite acid plant, also for measuring the lime kiln temperatures at the kraft mill. This latter is an unusual application of the thermocouple principle inasmuch as the thermocouple is located outside of the heat zone within a telescopic arrangement. This telescope is focused on the hot zone of the lime kiln and the radiant heat rays are directed by the lenses and mirrors to the thermocouple.

Flow Indicating, Recording and Control Equipment:

Equipment for the flow measurement of liquids travelling at low velocities may be very simple as in the common displacement type of meter which is used on the average water supply to residences. However, in industry where it is desirous to measure such fluids as steam which may be travelling at velocities up to 10,000 feet per minute, the differential pressure type of flow meter is commonly used. This type of flow meter works on the principle that if an obstruction be placed in a pipe line through which the medium is flowing there will be an increase in velocity at the point of obstruction. There are two general methods of designing this obstruction and the first is known as the Venturi tube, which is fabricated as a section of the pipe to be inserted in the line, this section having a tapered inlet section which tapers down to the throat of the tube and that section from the throat to the exit end of the tube being tapered back to the full pipe size diameter. A simple modification of the same principle is made by inserting an orifice between two flanges in the pipe line, the diameter of the orifice being less than the normal diameter of the pipe line.

The increase in velocity through the throat of the Venturi tube or through the restricted section of the orifice plate causes a decrease in pressure on the downstream side of the restriction. Thus if we connect a U tube, one end of the upstream side of the Venturi throat orifice and the other end to the downstream side we can indicate a differential pressure between these two locations. Such a U tube is called a manometer. In the manometer of the mechanical type of flow meter this differential pressure is generally caused to raise the level of a body of mercury upon which a float may be resting. This float may be mechanically linked to various mechanisms which may either indicate, record or control the flow passing through this pipe line.

It is often desirable to place the indicating, recording, or control equipment at some distance from the point of measurement in the pipe line, and for such an application the electrically operated differential flow meter is used. The differential principles are exactly the same as in a mechanical type meter but instead of the float resting on the mercury, being linked to a mechanism, this float may be connected to an armature within a non-magnetic tube which confines the fluid pressure. A divided inductance coil is located outside the non-magnetic tube and when connected with a source of alternating current the ratio between the voltages across the two parts of the coil is governed by the position of the armature within the tube. Similar divided inductance coils with counterbalanced armatures in indicating, recording or controlling instruments may be connected with the coil of the differential flow meter on the Inductance Bridge Principle and thus the armatures in the instruments will move in synchronism with one another and the flow of the fluid may be indicated, recorded, or controlled at a remote location.

In one type of electrical flow meter resistance elements are inserted in the mercury manometer itself, and with a change in level in the mercury due to change in flow, additional contacts are brought into the circuit, and the increase in current flow through the circuit is recorded and calibrated in units of flow of the medium to be measured.

In another type of electrically operated flow meter the downstream side of the manometer tube encloses the laminations of the secondary side of an A. C. transformer. Therefore, with a rise in mercury level due to an increase in flow, the resistance of the secondary circuit is lowered resulting in an increased flow of current in the primary circuit. This is measured by electrical instruments which are calibrated in units of flow of the fluid in the pipe line.

(Note the term "fluid" in this chapter applies to gases and vapors in addition to its customary reference to liquids.)

One of the disadvantages of the differential pressure type of flow meters is its lack of accuracy at the lower ranges of its operation. This is an inherent weakness due to the fact that the ratio between flow and differential pressure follows a square root law. Thus if a meter orifice ratio is designed to create a differential pressure of 100 inches of water at 10,000 per hour maximum rate of flow, then at 1,000 per hour rate of flow or 10% of maximum capacity the differential would equal only one inch of water or 1% of the maximum differential.

For this reason manufacturers limit their accuracy guarantees of 2% plus or minus only at rates of flow between the maximum for which the meter is designed and 25% of that maximum.

Another interesting development in the line of flow indication is called a Rotometer. This equipment uses a cylindrical hollow tube the inside diameter of which is tapered. For the measurements of acid under low pressure this tube may be made of glass. Inside of the tube is mounted a small metal stopper which has the same diameter as the diameter of the small end of the tapered tube. (The tube must be mounted in a vertical position with the small end of the tapered tube at the bottom.) When the flow through the tube is 0 the metal stopper rests at the bottom of the tube but when the flow of the medium is created the stopper will rise to a point where the annular space between the stopper and the wall of the tube is sufficient to allow that amount of liquid to pass. It is evident that if the tube gradually increases in diameter from the bottom to the top that the higher the stopper is elevated the greater will be the area of the annular space surrounding the stopper. The resultant position of the stopper for any degree of flow may be calibrated on a scale on the outside of this glass tube and thereby become a means of flow indication. Equipment has also been supplemented to make this stopper act as a solenoid in an electrical circuit and thus electrically record the rate of flow as indicated by the stopper position.

For the measurement of viscous fluids as Fuel Oils, Tars, Heavy Distillates, etc., an AREA FLOW METER has been developed. This is a constant head, variable orifice type of meter in which the differential pressure is held constant by balancing the weight of a piston against the pressure drop across an orifice contained in the meter body.

The meter body is designed similar to a globe valve, the orifice being cut in a cylindrical sleeve, and the piston acting like a disc on a globe valve.

The position of the piston in the meter body and therefore the relative capacity of the orifice is transmitted electrically by the inductance bridge principle to the indicator or recorder. The electrical system is identical with one previously mentioned in connection with an electrical differential

type Flow Meter. We have one application of this type of recording flow meter measuring fuel oil to the kraft mill lime kiln oil burners.

In general, these different classifications of flow measuring equipment are made as follows: For measurement of small quantities of water flow, also of fuel oil, the displacement type of meter is used. For the measurement of large volumes of water and for water under high pressure and also for the measurement of steam flow the Venturi or orifice differential type of meters are used. The only application we have at Camas of the Rotometer is on the new experimental digester where it was desirable to indicate relatively small rates of flow of the cooking acid being circulated through the acid heater.

There is one interesting application in the Camas Mill of an automatic time flow control, which is being applied to the indirect cooking of sulphite pulp. The time flow control is operated in conjunction with the automatic top relief for controlling the digester pressure. In the operation of this equipment it is first necessary to have recorded the rate of steam flow and the corresponding digester temperature and pressure rise which has resulted in the desired grade of pulp. Then neglecting variables in the cooking acid and the wood a reproduction of this rate of steam flow to the digester will result in a similar quality of pulp. This is done by reproducing the rate of steam flow (from the established standard cook) to a metal cam. The cam is then mounted on the spindle of the steam flow control unit and when the digester is in readiness the master steam valve is opened fully. From this point on to the end of the cooking cycle, the air operated steam admission valve is automatically controlled.

Different cams may be cut for different cooking conditions or grades of pulp.

In the new sulphite experimental digester a similar automatic arrangement is used but instead of the rate of steam flow being the controlling point, the temperature of the cooking acid leaving the acid heater is used. Thus we have two different systems for the cooking of sulphite pulp, i.e., an automatic time flow control and automatic time temperature control, both of which are used in conjunction with automatic top relief for the control of digester pressure.

The Verigraph, an instrument for controlling the moisture content of paper in the dryer section of a paper machine is a very interesting development and is briefly outlined in the chapter on "Paper Machines"—**DRYING.**

CHAPTER XXXVII

INDUSTRIAL WASTE AND EFFICIENCY

By A. R. HERON

Many elements of industrial waste and efficiency will find their way into other discussions in this book, dealing with production problems.

So much has been printed on the subject that a single brief discussion can point out only the most obvious features of the problem. A more complete discussion of even these features could fill a small library.

The problem is large in total dollars involved. When the national income was estimated at some sixty billion dollars, a broad study placed preventable waste in industry at fifteen billion dollars a year. The problem is also large in total numbers who suffer. Since 80% of the total national income goes to labor in some form, 80% of the annual waste is a burden on those who work. And it clearly is equally large in total numbers of those who help to cause it.

What Is Waste?

A first step is to center the discussion on wastes as distinguished from mere losses. There are many losses which are the result of waste on the part of one person, but not truly "economic loss," or waste in the sense of this discussion.

Fraudulent promotions, fake services, the whole group of "gold brick" schemes, are in this class. With them may be grouped losses by theft. In losses of these kinds, the first owner suffers from waste, by losing money or other value without receiving value in return. But the value itself is not destroyed; it merely changes hands. The only true economic loss is the value which the time and talent of the fake promoter, the thief or the burglar, could have created. Society at large has lost the potential value of his time well used, because he chose to devote it to the basically worthless purpose of selling nothing for something, getting something for nothing. He has failed to create, but he has not destroyed.

A second form of waste needs to be identified so as to define and limit the subject of this discussion. It is the permitted destruction or dissipation of known values by lack of knowledge or will for their conservation or utilization. These permitted wastes are largely matters on which honest opinions may differ.

The reality of the waste of the annual run-off of a great watershed may be challenged by those who deny the need of the potential values of storing the water; power development, flood control, irrigation, navigation. It may be challenged by those who admit such values but contend that they do not justify the required investment.

A third class of waste needs to be mentioned and largely, although not completely, omitted from the immediate discussion. That is the destruction of known values as an incident to the recovery or creation of other values. The sulphite pulp process, in the recovery of cellulose, largely destroys the potential value of the lignin content of the wood. The construction of a great water storage and utilization project, by the building of its dams, threatens the value of the annual fish catch. The recovery of gold by such processes as the dredger destroys potential food-producing farm lands. The reality of these apparent wastes is debated between those who value the created or recovered wealth as greater than the destroyed or dissipated wealth, and those who deny such excess value.

Industrial Waste

Passing from these debatable forms of waste to those which directly concern our subject, industrial waste may be studied in three major forms. They are here named in the order of our ability to recognize them:

1. Waste of material things.
2. Waste of power or energy other than human energy.
3. Waste of time, or of human energy.

It happens that this order is exactly the reverse of the order of importance in the modern industrial age.

We have a vague sense of moral wrong in the destruction of a material thing which, in its creation or processing, has absorbed the work of human hands, but we see this waste more readily when it affects a material thing.

Of the common forms of industrial waste of material things, the one which we see most readily, which is most spectacular, which is most clearly preventable, is the loss by fire. This loss in the United States is nearly five hundred million dollars per year. Of this over two hundred million dollars is industrial loss, the destruction by fire of material things used in industry. The fact that this loss is insured does not affect the reality of the loss or waste. The insurance premiums are merely the method of spreading this loss more evenly, and of providing the money in advance to replace the loss. Every dollar of fire insurance premium which industry pays represents a part of this huge industrial waste.

While this is a serious waste in a single form, compared with the estimated total of industrial waste quoted above it is small. The fire waste

impresses us because it is so obvious. The more costly wastes do not impress us because they are less visible.

Spoilage of materials in process is another obvious form of the waste of material things. Beyond the experimental stage of a process, it is one of the most easily preventable wastes. Its prevention is the function of human beings, through care, skill and determination.

Waste of equipment involves the destruction of the work of other human hands in two ways. It not only means destruction of the work of those who made or processed the equipment, but of those whose creation of values in past years was saved to form the "capital" with which the equipment was paid for.

Greater than losses by fire or accident are those losses of equipment through lack of attention to its proper care. Faulty maintenance is the human cause of most equipment waste in the form of loss of the material thing itself.

Equipment values are wasted when the product of the machine is spoiled. Even more serious is the waste of equipment through its non-use, or its use below its normal capacity. Perhaps this form of waste is one of the most difficult for which to fix the responsibility, one of the easiest to excuse.

When equipment stands idle because it has been built beyond the need for its product, there is an obvious waste. Whose responsibility is it? When equipment stands idle because of lack of power, lack of processing materials, lack of maintenance, lack of labor, there is the same obvious waste. Whose responsibility is it? When equipment stands idle because of a sudden reduction in the market for its products, there is obvious waste. Whose responsibility is it?

In one case we have the answer. When equipment stands idle, or operates at a fraction of its normal speed or capacity, due to inefficient operation, whose responsibility is it? The operator's, his supervisor's, his superintendent's.

The industrial waste of equipment values through non-use or incomplete use far exceeds the industrial loss by fire. This form of equipment waste is doubly serious in the pulp and paper industry. Here the value of equipment per worker employed is nearly three times as great as the average in all manufacturing industries. Therefore the probability of waste through non-use of equipment places on each of us a responsibility three times as great as in most industries.

Another form of waste of material things is serious in its total volume but easy to overlook. It is the non-use of materials. Incomplete combustion

of fuel is waste, usually irrecoverable waste. Waste of heat in any form is literally so much wealth "gone up in smoke." Waste of timber values by the hasty primitive logging of the early days is being paid for today by every one of us.

The loss of lignin in the sulphite waste liquor has already been mentioned. The answer that we do not yet know how to conserve it must pass for the present. A chemical profession which has made perfume and ivory and flavoring extracts and a hundred drugs out of coal tar can be trusted to turn this waste into recovered wealth. In the meantime we are sending cellulose fibers to the sewers in white water, and prime wood to the burners in saw kerf.

Passing from wastes of material things, the waste of energy other than human energy deserves a brief reference. It is present in many of the incidents already mentioned. Spoiled product in our industry includes the waste of steam and electricity already used in the process. Many of our visible wastes include a further waste of power in some form. It usually requires a conveyor to transport the saw kerf from a sawmill.

Industry does not display such absurdities as putting neon signs at the North Pole, but any day in some relatively efficient mill, you may find electricity wasting itself in uneven competition with sunlight.

We pass rapidly from these wastes of material things and non-human energies to the waste which is not only directly greater, but which is also the largest element in any material waste—the waste of human time and energy.

This human waste has form which is beyond our comprehension, either as to size or cause or cure. The destruction of lives by war is waste. So is the use of millions of years of other lives to accomplish this destruction. The devotion of human time and effort to the creation of useless things is waste—and the things created are useless when they give neither food nor clothing nor housing nor pleasure nor knowledge nor beauty. We have engaged for years in this form of waste on the scale of a world-wide war, and largely for like reasons. We had a depression to conquer, and we knew no other way.

When we see a figure of debt resulting from war, or non-productive spending, will it make the sense of loss and waste more real if we think this truth: "Eighty percent of that figure represents the time and energy of my brothers" When we see a factory or a home or a store going up in flames, will we feel the heat more keenly if we say: "Eighty per cent of that represents the time and strength of human beings?"

Wars and depressions and fires, with their tragic waste of human

energy, do not happen every day. But equally real and even larger wastes of human time and energy do.

The average large industry in the United States loses five percent of the time of its workers through illness. Aside from the cost of medical care, this loss measured in wages alone is between two and three billion dollars a year—ten times the industrial loss by fire. This loss of employed time is actual economic waste. The goods which could have been produced, the service which could have been rendered, on those days of illness, has been lost forever. More emphatically it is waste insofar as it is preventable. Science is doing its part. Many of the scourges and plagues of the past generation have been conquered. Typhoid and malaria have almost disappeared, tuberculosis is on the way out. The common causes of industrial waste through illness are largely those which you and I can control. The worst of all, the common cold, calls for reasonable care in our daily lives.

Another of the biggest of industry's waste of human time and energy is the toll of industrial accidents. The fact that this loss has been partly spread over industry as a whole effects no total saving.

This loss to industry, shared by all who work in industry, is too large to be conceived. The losses of life by industrial accidents in the United States each year are more than the total number of American soldiers killed in action in the World War. In our own industry alone, the money cost of accidents, in medical care and compensation, if it could be saved, could add millions of dollars to our pay envelopes. For American industry as a whole, the loss of production represents a waste of billions of dollars every year.

Is this a preventable waste? Certainly it is reducible, for it has been reduced. Governments are spending millions, industry has spent billions, on the problem. Physical hazards have been largely removed, mechanical hazards have been guarded. Why and how do accidents continue to happen?

Only 12% of all accidents in industry occur in connection with machinery. Over 26% occur in handling objects; 18% from falls, more than half of these from falling on the same level. About 8% occur from using hand tools, about 6% from stepping on or striking objects. Nearly 80% occur from something the victim did himself. He was too hurried, or too slow, too careless, too brave, too thoughtless.

Loss of production, loss of earnings, and more important, loss of life and limb, and human suffering, make this a field worth while for the reduction of industrial waste.

Loss of Time—The Most Expensive Waste

Last of all, greatest of all in cost, is the loss of human time and energy

which is simply not used. This responsibility rests on each of us. Each of us is largely the custodian and trustee of his own time and energy and ability. No one of us can claim to have made full use of the time and energy which he directly controls. But there are other phases in which we share the responsibility with many others.

The first and greatest cause of this industrial waste is our ignorance of its existence. Men who work have a right to know whether all their work is useful, whether it can be made easier or shorter. They have a right to know whether their time, this part of their lives, is being wasted by needless motions, needless waiting for materials, needless machine delays, needless defects in materials and processes. One of the largest manufacturing industries in the United States has been attacking this waste for twenty years. Its workers, highly organized, have enlisted with management in the study of standards. They have attacked the organization of processes, the routing of work, the allotment of time. They have smoothed the flow, eliminated bottlenecks, corrected errors at their sources, increased the output per worker and increased the earnings per worker. In an outstanding example of cooperation between employers and organized labor, they have made use of the scientific processes of time and motion study, jointly conducted. And they have given us our clothing at a lower cost, and you and I have given them more work to do for us.

Our first need is knowledge. How much of our time is being wasted? How much of our possible production is being lost to the community? Under any name, industry and its workers need a study of methods and standards, to measure the loss and waste of workers' time. As workers become better organized, better served by their representatives, they are beginning to demand these studies and standards, this knowledge about the waste of their priceless value—Time.

After this knowledge we need cooperation. This means readiness by management to provide the necessary investment and planning, and to recognize the justice of sharing the savings. It means cooperation by workers in accomplishing the savings. It means the cooperation of the consumer in the absorption of more of the products of industry.

To get this cycle of cooperation we need no new laws or agreements. We need no artificial controls of production or distribution. The elimination of this waste means easier work for the man at the bench. It means lower costs to the industry-owner. It means lower prices to the buying public. It means larger sales and consumption. It means more employment at the bench. Carried to other industries it means that each of us can have a more bountiful supply of his needs, a higher and higher standard of living.

To recognize waste in any form; to recognize it as a loss to us as

individuals; to cooperate in eliminating it; to look for it and cure it close at hand, in the day's work, largely by common horse sense — this is Industrial Efficiency.

CHAPTER XXXVIII

MANUFACTURE OF NEWSPRINT AT WEST LINN

By C. A. ENGHOUSE and B. WEIDENBAUM

Historians have often spoken of man's progress being measured by the ability to convey his thoughts to his fellowmen. With the evolution of civilization from the cave-dwelling aborigines to our present day highly developed, world conscious, national group, there has been a change in the method of disseminating knowledge and information of general interest. The guttural gibberings of early man were his only method of distributing the affairs of the group amongst it. A later development was the setting in stone of the laws and happenings of the tribe. Development was slow and of a minor nature until the advent of the printing press.

With the development of the first printing press the thought to be expressed could be set down in fairly permanent fashion, and many times over in a short space of time. It was almost four hundred years later that the first simple press with removable type had been improved to the extent where its use was practical in high speed production of printed sheets. This was contingent on advances in technology and the sciences, and the inventive genius of the men who wrestled with the problem of obtaining high speed in printing processes.

In comparatively recent years presses have been improved further and their scope of utility increased. In the development of the printing press, the paper used in it was always of prime importance, and even today poor printing is often the fault of the paper. Newspaper presses require a sheet of very definite characteristics and newsprint is continually being improved so that it can be used for half-tone reproductions, multi-color printing, and the other processes that are employed in newspaper publishing.

Although the operating conditions are peculiar to each individual mill, we shall consider the West Linn Mill of the Crown Zellerbach Corporation as representative of mills engaging in the manufacture of newsprint and ground wood specialties.

Standard Newsprint

This mill manufactures standard newsprint, which is a 32-pound (24 x 36—500) basis weight sheet, for use in the western part of the United States. The sheet is made in cream-white shade to conform with the customer's desires, and also in a variety of colors as required. In addition,

sheet news is also supplied. This is essentially the same as standard news-print but is trimmed in flat sheets for use in presses of the flat-bed type.

Sheet news is supplied in two grades, Crown printers sheet news and Crown flat-bed news. The difference between the two grades is only in the finish. The printer's sheet news has a higher finish than the flat-bed news. The respective caliper figures are 0.0033-0.0034 inches for printer's sheet news and 0.0037-0.0039 inches for flat-bed news.

Since there is little degree of permanence required of newsprint—it is used to be printed, read, and disposed of in a comparatively short time—groundwood, or mechanical pulp, can be used to the degree that machine operating conditions will permit. Although the groundwood contains lignin, tannins, and other materials removed in the chemical pulping of wood, and which discolor on exposure to light and air, the premise that the newsprint will be utilized soon after manufacture permits the use of a furnish which is mostly groundwood.

The percentage of sulphite in the furnish for a newsprint sheet will vary with the speed of the paper machine, as a general rule. The slower the speed, the less sulphite will be required. At West Linn, machines operating at 600 feet per minute will require from 8 to 10 percent sulphite pulp, whereas a machine operating at 1100 feet per minute will require 14 to 20 percent sulphite. The sulphite pulp provides sufficient strength to the sheet on the wire, i.e., wet strength, to reduce operating difficulties to a minimum. Generally a sheet that has sufficient strength not to cause breaks on the machine has sufficient strength not to cause trouble due to breaks at the printing press. It is very important that the consistency of the groundwood and sulphite being supplied to the machine be maintained with very little variation, since the percentage of each pulp in the furnish depends on the consistency at which it is being pumped to the mixers.

Newsprint is unsized since the printing is accomplished by penetration of the oil vehicle of the ink into the sheet. This leaves a coating of the pigment on the surface of the paper. A sized sheet would retard the rate of penetration of the ink and trouble would result from smudging and offset unless more expensive inks were used.

Alum to the extent of $1\frac{1}{2}$ pounds per ton is added to the furnish. The purpose of the alum is to regulate the acidity of the system, thus fixing the color when anilines or coloring matter are used. An acid condition is maintained in the system as it is a characteristic of western groundwood to dull as the acidity approaches the neutral point.

Although newsprint represents the bulk of the paper made at West Linn, other grades with a high groundwood content are also made and will be considered.

Groundwood Specialties

Telephone Directory Paper is made in several different basis weights ranging from 24 pound to 32 pound basis 24 x 36—500. These are made both in yellow and white. The requirements of this grade of paper are occasioned by the need of a bright sheet to facilitate reading the fairly fine print and numbers that are listed. In order to reduce the amount of show-through, a filler is added. This grade uses a slower groundwood than newsprint, and which is made with artificial stones entirely. The freeness at the deckers for standard newsprint averages approximately 75 C. S. (Canadian Standard), whereas for directory furnish a groundwood having a freeness of from 40-45 C. S. is used. This slower groundwood will be on the average shorter fibered and more fibrillated than the freer stock used for standard newsprint. This gives more refracting surfaces in the sheet and tends to increase the opacity. The required brightness of the white directory paper is obtained by using bleached sulphite and also by grinding selected wood. The filler also aids in brightening the sheet and improves the printing qualities.

Special Magazine News of various qualities is manufactured. A 34 pound (24 x 36—500) basis weight sheet is made for colored magazine sections published by various newspapers. This sheet is similar to standard newsprint in furnish. Particular attention is given to finish and formation since color printing in national advertisements is carried in these magazine sections. Other sheets in basis weights from 35 pound to 45 pound (24 x 36—500) are made according to the customer's requirements. These invariably call for the use of bleached sulphite to the extent of 25 to 45 percent and a filler content is used to help brighten the sheet. These sheets must be suitable for the special requirements of color presses.

Hanging Stock, the base stock for printed wall paper, is a more specialized sheet. Requirements, which are dictated by the particular use to which it is put, are that it will be a very uniform sheet, such that it will print well; next it must be sized and well closed so that the sheet does not take up too much paste when hung, and so that the paste does not penetrate through the sheet and stain the printed side. This sheet, having a bulk index of about 140, is bulkier than newsprint, which runs about 100. To obtain this bulkiness it is necessary to grind a long-fibered groundwood. With this groundwood, about 25 percent sulphite is necessary to give the sheet the required strength. This grade is made in 37 pound (24 x 36—500) basis weight. Very little calendering is applied to assist in obtaining the desired bulk.

News Liner is a sheet used to cover chipboard or other board

material. These boards are usually printed on the lined surfaces and then fabricated into boxes or other containers. This sheet is manufactured at 34 pounds (24 x 36—500) basis weight and must be very uniform. The finish is high and even. This insures a good printing surface. A very bright sheet is obtained by using as much as 50 percent bleached sulphite and the required opacity by the use of filler to the extent of about 10 to 12 percent. Brightness is necessary to enhance the attractiveness of the printing and the package; high opacity is needed in order that the chipboard or other material which has been lined is completely masked.

Pulp Mills

The grades of paper considered all require groundwood and sulphite pulp in their manufacture. West Linn mill operates a groundwood mill and a sulphite unit to furnish its needs with respect to pulp. Since the requirements for bleached pulp are comparatively small, this stock is obtained elsewhere. No attempt will be made to give a detailed account of the pulping mills, since these processes are very well described elsewhere in this book, and our discussion will therefore be of a more or less general nature.

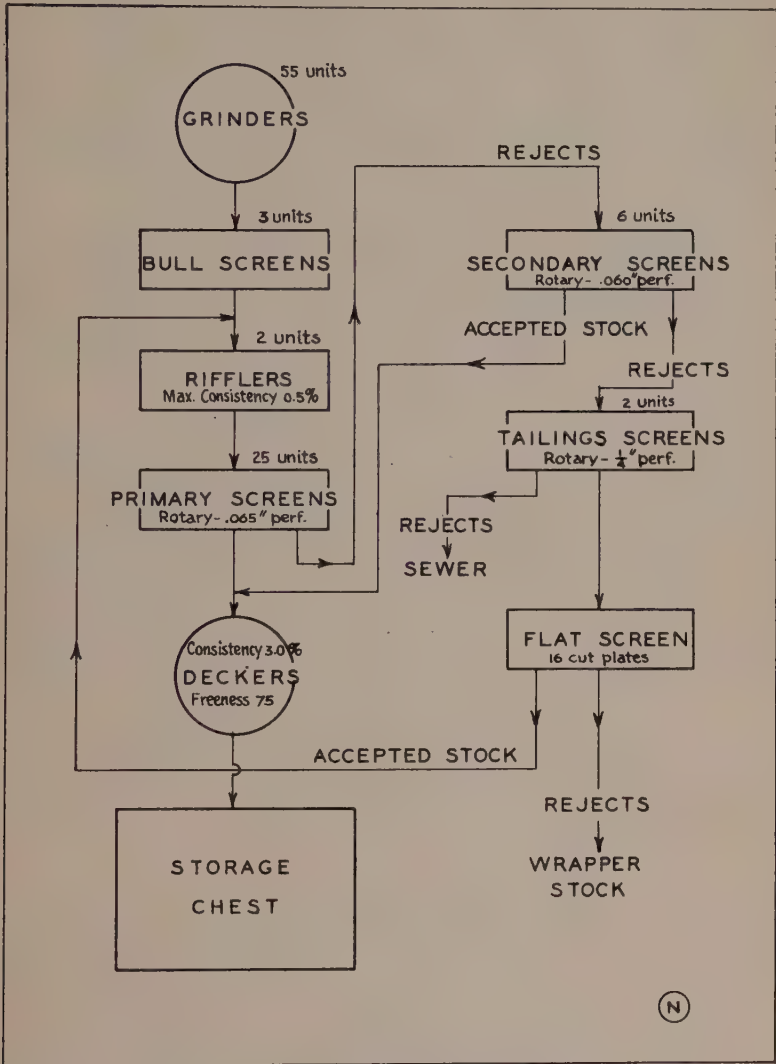
Groundwood

Groundwood, or mechanical pulp, is made by disintegrating into wood fibers blocks of wood held against revolving stones. In early mills, the power required for this purpose was economically supplied by water wheels, and hence, mills would always be located by a water-way from which power could be developed. Such locations would be contingent on an adequate wood supply close at hand and convenient transportation facilities. The latter, as well as the water necessary for the various phases of manufacture, would be supplied by the water-way itself.

At West Linn there are 55 stones available for grinding groundwood. Of these 28 are artificial stones and 27 are natural stones from sandstone quarries. Water power operates 50 of these stones and electric power is used to drive five of them. The head of water available for the hydraulic grinders will vary from 30 to 45 feet in the course of the year. For this reason sufficient pulp is ground during the period of high water to help take care of the requirements of the period of low water. Turbines are of the high volume low head type. The method of handling this pulp is unique and will be discussed later.

The groundwood in the grinder pits contains sand, slivers, shives and other materials which are undesirable in the pulp. These are removed in the conventional manner, which is described in the chapter on screening,

and so our remarks will be confined to a brief description of the particular equipment used at West Linn.



stock then goes to riffles, approximately 30 feet wide and 50 feet long, comprising concrete baffles set vertically at about three foot intervals.

The stock at about 0.5 percent consistency then enters the primary screens consisting of the usual rotary screens with .065 perforated screen plates. The rejected stock from these screens goes to the secondary screens. These also are rotary screens and have .060 perforated screen plates. The accepted stock from both the primary and secondary screens goes to the deckers where sufficient water is removed to give the deckered stock a consistency of 3.0 percent, the desired consistency for use in the mixer room. The deckers are of the couch type, and the couch roll is made of rubber rather than the jacketed type, thereby eliminating the hazard of wool fibers in the stock furnish passing to the machine. A flow sheet of the screening system is shown in Fig. 167

The rejects from the secondary screen go to a rotary screen that has $\frac{1}{4}$ -inch perforations. Material rejected from this screen goes to the sewer and accepted stock goes to a line of flat screens which have .016" cut plates. The accepted stock from the flat screens is returned to the riffles. The rejected material from the flat screens is then pressed to remove the water and subsequently used in wrapper stock.

As previously mentioned, during the period of high water sufficient stock is ground and stored to take care of the period when the river is too low to be able to use all the grinders. This pulp is riffled and screened as described above, then pumped to a set of wet machines supplemented by vacuum filters. The stock is lapped to a consistency of about 18 to 20 percent and removed from the forming roll by doctor blades which skin the pulp off. The pulp drops to a conveyor belt which brings it to a multi-cell compressed air ejector. The cells are part of a constantly revolving frame. As each cell comes below the chute at the end of the conveyor belt it is filled with the "noodled" pulp. This pulp is ejected by means of compressed air through a pipe line to the storage yard. When it is to be used it is sluiced with a jet of water to a mixing tank which then feeds it to the screening system.

Sulphite Mill

As mentioned previously, newsprint furnish requires varying amounts of sulphite to give the necessary strength to the sheet. For this purpose, a "news" sulphite is used. This is obtained by cooking to give a very hard stock, the pulp having a chlorine number of approximately 6.0.

West Linn employs the Chemi-Pulp system for making sulphite pulp. There are four $11\frac{1}{2}$ -ton digesters measuring 15 feet in diameter by 49 feet in height. The fifth, which is 18 x 50, is used as a hot acid accumulator. Total cooking time will vary from nine to ten hours, the first one-half to one and one-half hours of which will be used for pre-circulating the cooking

acid. Maximum temperatures of 286-288 degrees Fahrenheit and a maximum pressure of 75 pounds are ordinarily attained. The composition of the cooking acid shows some seasonal variation but will have an average total SO_2 of 6.00; free of 4.80; and combined of 1.20.

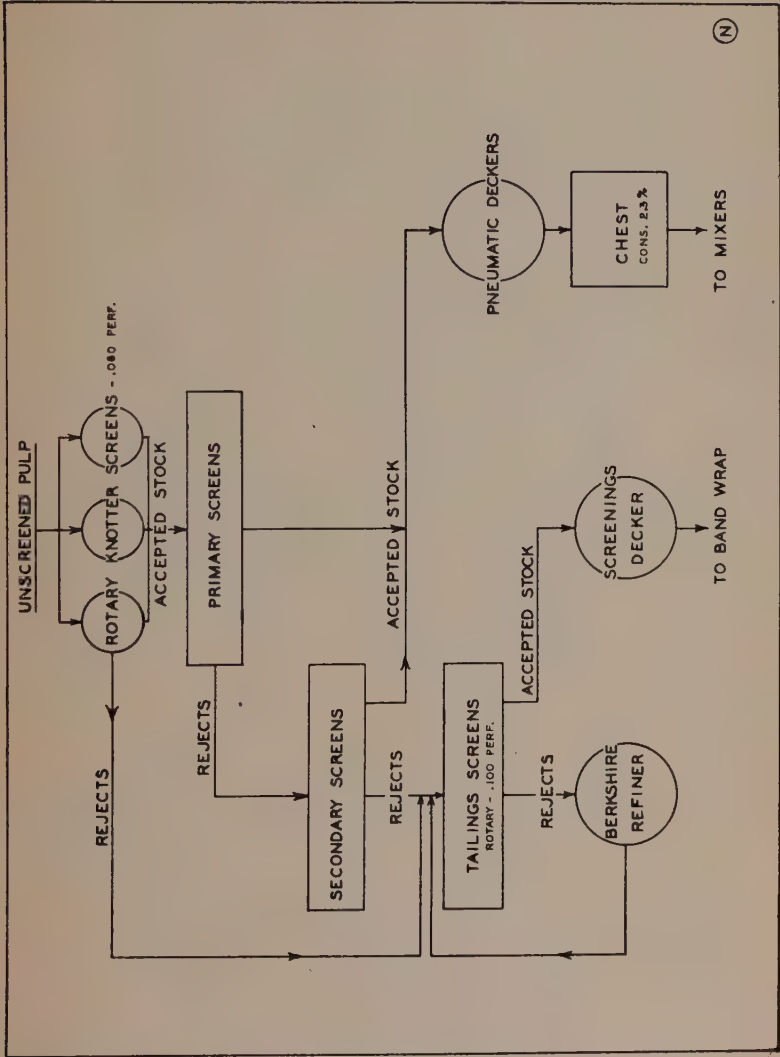


Fig. 168
Flow Sheet of Sulphite Screening Systems.

The cooked pulp is blown into blow pits and washed in the customary manner. Washed pulp is pumped to a set of knotters to remove uncooked material, then to the rotary primary screens with .060" perforated plates.

Rejects from the primary screens go to the secondary screens, comprising a line of flat screens consisting of plates of various cut to suit the operating conditions. Accepted stock from both primary and secondary screens goes to pneumatic deckers where the pulp is de-watered to produce stock with a consistency of 2.3 percent; this stock is then ready to be used in the mixers.

The rejected material from the flat screens goes through a rotary tailing screen with .100" perforated plates. Screenings accepted by this screen are deckered and used in roll wrap. The rejected material goes to a Berkshire refiner where it is disintegrated and recirculated to the tailing screen, so that this part of the screening system is closed and the coarse and large material is refined until it ultimately is acceptable for roll wrap.

Mixer Room

There are no beaters used in the manufacture of newsprint at West Linn and the entire refining treatment given the stock is with jordan. Inasmuch as one of the functions of the beater is to mix thoroughly the various constituents that make up a furnish, mixers are used. These are concrete tanks, tile lined, and equipped with agitators. There are five of these each with a capacity of 4500 pounds air dry fiber basis, and one of 2250 pounds. The stock goes from the mixer to a stock chest and thence to the jordan, it being understood that each machine (or in one case, two machines) has its own mixer. The groundwood is pumped to the mixer at a consistency of 3.0 percent and the sulphite at 2.3 percent. In order to minimize machine operating difficulty due to variation of freeness of the head box mixture, it is very essential that these consistencies be maintained with very little fluctuation. This is accomplished successfully with Warner equalizers.

To obtain the color desired in the various grades, anilines are added to the mixer furnish. Some of the more soluble basics, like safranine and auramine, are added dry, but for the most part the dyes are added after having been dispersed in water.

The several grades which require filler in the furnish, special magazine news, directory, and news liner, have it added in the necessary amount at the mixer. Talc is used almost exclusively and is added dry.

Directory paper, hanging stock, and news liner are all sized sheets. For this purpose rosin size is used and added to the mixer in the form of milk of rosin containing 0.3 pounds of solid rosin per gallon. The alum necessary to set the size and complete the furnish is added in dry form to the mixer following the addition of size and anilines.

When necessary to brighten the color of the groundwood, zinc hydro-

sulphite is used. When hydrosulphite is being used, the groundwood is added to the mixer first, then the zinc hydrosulphite before anything else is added. The mixture is allowed to stand as long as possible before the other constituents making up the furnish are added. This is done so that the hydrosulphite can exert its maximum influence on the groundwood without exhausting itself needlessly on the sulphite and other furnish ingredients, particularly the color.

Zinc hydrosulphite can be obtained commercially in powdered form, but as a general practice it is made up at the mill as needed as follows: Powdered zinc is slurried in water with good agitation, and sulphur dioxide bubbled in from a storage cylinder of liquid sulphur dioxide. Care must be taken to cool the mixture as the reaction proceeds with the evolution of heat and cooling coils are provided for this purpose. These carry water and regulate the temperature of the reacting mixture. When a light straw color has been reached, sufficient sulphur dioxide has been added and the zinc hydrosulphite is ready for use; its concentration is usually about three pounds per gallon.

Machine Room

Since newsprint is a commodity handled in a large tonnage and the margin for profitable operation per ton is small, it is essential that every possible economy be effected. For this reason the machines on which newsprint is manufactured have been made larger and larger and the operating speeds have been constantly increased. Mechanically, the limit in size and speed very likely has not yet been obtained, but it has been found that optimum operation on a cost basis is achieved on machines that are smaller than the largest ones made thus far and run at slower speeds than the fastest.

The stock for No. 9 machine at West Linn, which is a typical modern high speed news machine, passes from the mixer tank to the jordan chest and thence to a Majestic bronze tackle jordan, where it is treated lightly in order to disintegrate broke and other lumps before it is delivered to the machine chest. At the fan pump the stock is diluted with white water as it passes to the head box which is equipped with lump breakers. Rectifier plates are used to give a quiet flow to the slice which is of a type developed at West Linn. The wires used are 60 and 65 mesh, 79 feet 8 inches long and 165 inches wide, providing a trim of 154 inches and are usually run at a downhill pitch of about 9 inches. The Fourdrinier is equipped with the usual table rolls, splash boards, suction boxes, deckle boards and a suction couch roll.

In addition to three presses, the first of which is of the suction type,

this machine is equipped with a smoothing press. The wet felts used are somewhat coarser than those used on machines making specialty paper grades.

There are forty-four dryers arranged in two sections, the second of which is supplied with steam direct from the boiler house and with exhaust steam from the turbine-generator set used for the drive. The exhaust from the second section is utilized in the first section by flashing the condensate and using the flash steam. The dryer section is equipped with a Ross-Grewin, hot air circulating system which increases the efficiency of this operation and minimizes the condensation in the exhaust gases going to the hood. This machine is also equipped with felt dryers.



Fig. 169
Fourdrinier Paper Machine

Standard newsprint requires a fairly high finish and therefore a full calender stack of seven nips with one roll riding is used. In order to obtain this finish without blackening the sheet, careful regulation must be made of the moisture content. This is done by a Verigraph control system which regulates the amount of steam into the dryers to give the desired moisture content in the sheet leaving the dryer.

This machine has a sectional drive which is the first one that was installed by the General Electric Company on a large newsprint machine. Each of the eight sections is driven by its own D.C. motor. Power for the entire drive is furnished by a steam turbine which energizes a D.C. generator. A synchronous motor between the turbine and generator utilizes

the excess power generated by the turbine and supplies power to the system when the demand exceeds that being supplied by the turbine. The motors on each drive section are coupled to a synchronous motor by means of cone pulleys. These synchronous motors float across a common line and regulate the speed so that the speed of each section can be maintained to compensate for changes in dimension as the sheet is dried, in other words, to maintain a constant sheet tension or "draw".

Finishing Room

In order to insure the rolls of newsprint reaching the customer in good condition, it is necessary that great care be taken in wrapping the rolls. At the present time the rolls are wound on a three-inch core, made of 195 pound (24 x 36—480) stock and wound at the mill. Originally, split wooden cores were used, but paper cores have replaced these entirely.

To minimize the presence of atmospheric wrinkles and piping in the outer layers of the roll, a ply of asphalt laminated wrapper is put on the roll. Next $1\frac{1}{4}$ turns of a 125 pound (24 x 36—480) body wrap are used. Bands are then put on the top and bottom of the roll. These bands are 10 inches wide and are wrapped four ply at the top of the roll and nine ply at the bottom to provide protection in transit. Three head wrappers of 125 pound (24 x 36—480) basis are used on the top and bottom. Two of these are placed inside the band wrap and the third pasted outside. The outside head has a rough finish in order to lessen the danger of slippage when the rolls are stacked one on top of another. The amount of wrap indicated above is typical for most customers, but since the customer must pay for the gross weight delivered, he may insist on a lower tare. In that case less wrap is used according to the customer's specifications.

Sheet news is cut to size on a duplex cutter, which also counts the cut sheets into reams. These are packed according to customer's instructions, using special wrappers.

Technical Department

In the manufacture of newsprint, as described in the foregoing pages, it will be recognized that constant attention must be paid to the various component factors at each stage of manufacture, from the grinder room to the finishing room. The responsibility of maintaining a high standard of quality rests with the Technical Department.

Of prime importance is the certainty that the product is meeting the needs and specifications of the customer. To insure this, the paper is tested very carefully in the course of manufacture for the various physical characteristics that serve to indicate the utility value of the sheet. This constant vigilance on the part of the Technical Department also assures the cus-

tomer that uniformity will be maintained from one order to another, eliminating inconvenience due to variation in quality.

In similar fashion the Technical Department constantly tests and analyzes the raw materials going to the pulp mills and mixer room, as well as materials coming from these departments. In this way it is of service in maintaining quality control in the pulp mills themselves, as well as assuring the paper mill that a uniform furnish will be supplied to them so that they, in turn, will be able to manufacture a uniform product for the customer. Furthermore, the experience gained in the manufacture of one order is kept in permanent form by the Technical Department for use in repeat orders, so that a background of experience and data can be developed with a view to constant improvement both in processing and quality from run to run. This experience is also utilized to develop new grades of paper when the occasion for them arises, so that an intelligent approach can be made on the problems presented by the manufacture of the grade.

CHAPTER XXXIX

MILL ORGANIZATION and MILL MANAGEMENT PROBLEMS

By J. E. HANNY

A famous industrialist once said that industry is something like a three-legged stool. The three legs of the stool are Capital, Labor and Management. Unless all three of them function properly, the stool will not stand. In managing an organization the first consideration is to make enough money so that the bondholders and stockholders can receive a fair return on their investment. The affairs must be managed, so that interest can be paid to those who have loaned their money and made possible the building and operation of a plant. No one will loan money to a concern where they are not sure they are going to get a fair rate of interest, or their principal when they want it. If consideration is not given to those who have supplied the "capital," there might eventually come a time when money will be required to expand, to buy new and more up-to-date equipment, or even to carry on the necessary course of business, and unless a company is in good financial standing, they cannot expect to borrow money, and if they cannot get money to carry on, naturally they cannot operate any kind of a business.

Then, too, consideration must be given to employees. They must be given a fair wage, as high as can possibly be paid, in line with rates paid by competitors. They must be given good, comfortable, safe and pleasant places in which to work. Affairs must be managed, so that as far as possible, they can be given steady employment during the lean years as well as the prosperous.

There is nothing so essential in the operation of a plant as an efficient organization. We may have the best machinery that money can buy; our equipment may be laid out in the most efficient manner; and our Purchasing Department may obtain the best materials; yet, if the human factor is neglected, we will not have an efficient and successful operation.

This plant has become so large that it is impossible for the management to have the close contact that we would like to have with the employees. It is too bad that we do not have time to go around and talk to each of them at least once a week, discussing with them company policies and getting their ideas. On account of the impossibility of individual personal contact in a plant this size, it is recognized that the next best thing is to

have our supervisors and heads of departments act for us as managers of their respective departments, and we expect them to operate these departments as if they were the personal owners of them.

The following chart shows line-up of the Camas mill organization:

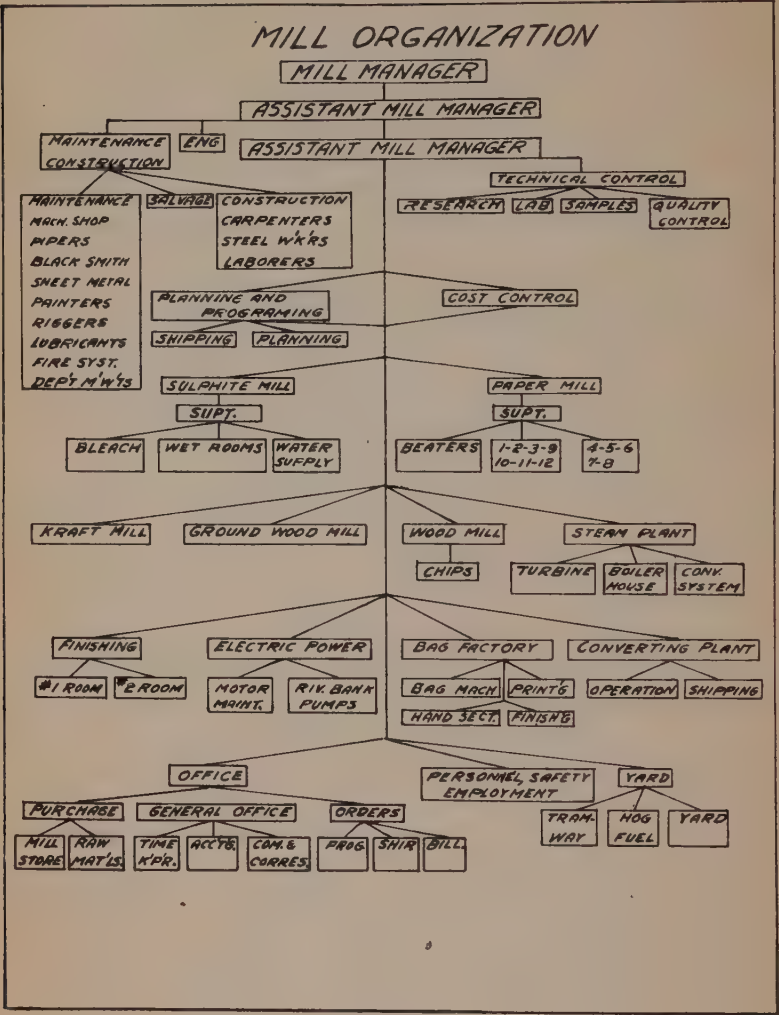


Fig. 170

Here are some of the things that we expect of a department head:

The first thing that we ask, of course: "Is his department clean and in order, so that he can turn out a first-class product in every respect at competitive cost?"

"Are all of his men at their places and working as if they were properly supervised?"

"Is his equipment maintained properly, so that he can produce maximum quantity and optimum quality?"

"Does he have the initiative to do the right thing without always being told?"

Then, too, we want to know that his equipment is well protected; that he has warned his employees against accident hazards. We want the right man on every job and want him to be physically fit for that job. We expect a department head to know what is going on in his department, to be alert and open-minded for new ideas, and discuss company policies with his men and encourage them to feel free to give their ideas. We also want him to cultivate that bearing and personality which characterize a good supervisor. Responsibilities gravitate to the person who can shoulder them, and we expect our supervisors and department heads to be able to assume responsibility.

"Management" has been defined as that art or science of preparing, organizing and directing human effort. In this plant, our greatest object is to turn out a high quality product at competitive cost. To do this, we must have the right kind of an operating force—one that is efficient and co-operative. It is surprising that with the numerous men seeking employment today, we sometimes find it difficult to get the right man for the right place. Unless this is done, we cannot expect high quality and low costs. I should like to quote from "The Busy Man's Creed," by Elbert Hubbard, which indicates the type of man we like to have:

"I believe in the stuff I am handing out, in the firm I am working for and in my ability to get results. I believe that honest stuff can be passed out to honest men by honest methods. I believe in working, not weeping; in boosting, not knocking; and in the pleasure of my job. I believe that a man gets what he goes after, that one deed done today is worth two deeds tomorrow, and that no man is down and out until he has lost faith in himself. I believe in today and the work I am doing; in tomorrow and the work I hope to do; and in the sure reward that the future holds. I believe in courtesy, in kindness, in generosity, in good cheer, in friendship and honest competition. I believe there is something to do, somewhere, for every man ready to do it."

This day is certainly a Buyer's Market and quality must be better than in previous times. Much has been done toward improving the quality of our products. Yet, we have a long way to go before we reach the goal for which we are striving.

So much has been said about quality and we have heard so much about it that we may become inclined to disregard it, but the very existence of this plant, or any other plant, depends upon quality improvement. Our opportunities for promotions and increased earnings depend upon the improvement of quality of our products. Results of poor quality and workmanship come back to us in complaints and loss of business. We cannot get away from it. Each individual in the Camas organization has some influence and bearing on the quality of our products, whether he is in the Logging Camps, Saw Mill, Pulp Mills, Paper Machines, Shipping, Clean-up, or any other of the numerous jobs.

Everyone should be as careful as possible all through the organization to follow specifications to the letter of the law. One supervisor or other employee making a mistake will nullify the good work done by many others. When mistakes are made and complaints received from the customers, we reduce sales, we reduce earning power, and there is then a subsequent reduction in the number of those employed and all the distress that comes with unemployment. There is an old saying, "If you make a better mousetrap, you will have a beaten path to your door." This also applies to paper products.

Management must direct employees so that they will consider this plant a good one in which to work and will at the same time put forth their best efforts. Management of employees is a vital part of a manager's job. A man can be ever so good a technician or engineer, but unless he knows how to handle men and get along with them, he will not become a successful supervisor. I think that above all things, he must treat his men so that they will have confidence in him; feel that they are going to get a square deal; that they will receive as high a rate as can be paid them; that they will have comfortable, safe and pleasant working conditions, and that there will be no discrimination against them. The employee should be made to feel that he will always get a fair hearing and a fair deal from his supervisor whenever wages or working conditions are discussed.

Company policies should be explained to the employees, so that they will have a clear understanding of them. Try to create an interest in their work; an interest for them to learn; an interest to get ahead. This is one of the reasons that we have the school on the manufacture of Pulp and Paper. We want the employees to be interested in their jobs. This is also the reason that we have numerous meetings to discuss costs and quality, and post data on the various bulletin boards throughout the plant. We want to get the idea across to our employees that they have something to work for.

Now I would like to review in a general way what this company is

doing for its employees and the community, as well as touch briefly upon some of the company policies.

I think that the Crown Zellerbach Corporation offers as much to its employees as any organization in the country. They have built here in Camas one of the largest specialty paper mills in the world, employing 1,750 men and women at the highest wage rates paid by this industry anywhere. Their products are universally known and sold all over the world. They have managed their affairs so well that they have never been in financial difficulty. By ingenuity and foresight, they have taken care of the peaks in demands so that most of the employees were retained in the organization through the difficult years of 1931 and 1932.

We have a mill here; in fact, all of the corporation's mills are so neat, orderly, sanitary and safe that they are set up as models by the state inspectors. "Plant cleanliness and safety" is one of our mottoes. This company has spent and is spending thousands of dollars every year to make this a safer and cleaner plant for its employees. Unless a man is thoroughly sold on the idea of safety and cleanliness, he can never expect to be a successful supervisor.



Fig. 171

The following pictures showing the lawns and flowers in every available space at Camas, including the space between the buildings, are familiar



Fig. 172



Fig. 173

sights. This is just one of the ways in which expenditures are being made to improve appearances and make this plant a more pleasant place for us to work.



Fig. 174

Several years ago the employees, with the cooperation of this company, started a Welfare Association. While the company at this time does not have any supervision over the Welfare Association, we do give it our moral support and have given financial aid. This association has been of real benefit to our employees.

A Federal Credit Union was organized here a few years ago and now has a membership of 360. This also has proved to be of value to the employees.

The employees are offered the services of the Camas Medical Association for a reasonable monthly rate, and this service has been subscribed to by a majority of the employees. They have also been offered Sick and Disability Insurance, as well as Group Life Insurance.

A great deal of time and study have been spent on First Aid work. About 500 employees have availed themselves of the opportunity of attending the school of standard instruction on First Aid and passed the necessary examinations. Fifty employees have passed not only the standard course,

but also the advanced course, and ten of these are now qualified to act as First Aid instructors. The First Aid team has taken part in demonstrations at various meetings in Oregon and Washington.

Several classes have been conducted in Public Speaking, and have been of value in developing those who have taken advantage of the opportunity to attend.

The Paper School started in 1933 and has grown rapidly, and we feel that it has been very successful. Lectures are given on every phase of pulp and paper manufacture by supervisors and members of the Technical Department, as well as outside speakers, who are authorities on paper manufacture. Various samples, drawings and slides are shown, and mill visits made. Regular examinations are held and diplomas given to the graduates. To date, 278 diplomas have been awarded to those completing the first year classes; 134 to the second year; 68 to the third year; and 30 to the fourth year.

Regarding the Suggestion System—employees are encouraged to submit any suggestion they may have for improved quality and operation. It is a company policy to pay for all accepted suggestions and awards are paid on the basis of a fair relationship to the first year's service. As a rule, suggestions are accepted only if they can pay for the cost of installation in two or three years. However, exceptions are made to this. Most suggestions pertaining to quality improvement are readily accepted, although in these cases, it is harder to determine what the reward shall be.

Service Pins. Approximately 1,185 of the 1,750 employees at this plant have been presented with service pins. There have been presented 522 5-year pins, 324 10-year, 194 15-year, 86 20-year, 36 25-year, 15 30-year, 6 35-year, and 2 40-year pins. The 5, 10 and 15-year pins are gold with the Crown Zellerbach emblem and the years of service shown on them. The 20-year pins are white gold with the emblem and years of service shown. The 25-year pins are similar to the 20-year pin with the addition of one diamond; and for each succeeding 5-year period, another diamond is added. The 5, 10 and 15-year pins are usually presented at a foremen's meeting by the resident manager, and the 20-year pins and above are presented by someone from our executive office.

We have a patent policy with which all of the employees are familiar. Before being presented to the employees, this policy was given a good deal of study for several years by our executives. They had investigated the patent policies of many other large companies, and I think that our's is one of the most generous policies offered. This patent policy, of course, is for the purpose of protecting both the employees and company. It is for the purpose of helping the employee develop his ideas, to protect them

and to get as much money as possible for the employee after the idea has been patented.

Advisory Committee. This committee consists of approximately 35 employees, who represent all of the departments of the plant, and meet with the manager at four meetings. Then they choose someone from their respective departments as succeed them. The purpose of this committee is to help the management get acquainted with the employees, to discuss company policies with them personally, and to get their counsel and ideas on plant operation. At these meetings, we invite criticism of any kind and it is a means of discussing problems that may affect our employees. We try to come to some understanding. This committee has helped the management a great deal and we think that much has been accomplished. In time, we hope that every employee in the plant will have served on this committee at some time or other.

In closing, I might say that man's business is to work, for work means security and happiness for himself and service to others. The best preparation for good work tomorrow is good work done today. If a fair day's work is done every day by each employee, there will be no "Management Problems."

